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ROENTGEN DIAGNOSIS AND TREATMENT OF PRIMARY PULMONARY NEOPLASM*

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I AM deeply appreciative of the honor of being asked to give this, the first Pancoast Lecture, and of the opportunity given me to pay tribute to a great physician. For Henry Pancoast was not only the leading Radiologist of his time, but he also occupied an important position as teacher, clinician, investigator and author in the world of medicine. Since the final evaluation of any man must be based on a comparison with his contemporaries in the general field of his endeavors, the high esteem in which Pancoast was held throughout the medical world was not only an indication of his worth as a Radiologist, but also did much to help the struggling young speciality to which he belonged.

The subject which I have chosen for presentation this evening is one in which Pancoast was deeply interested and to which he made a major contribution—his description of the clinical and roentgenological findings in malignant tumors arising in the superior pulmonary sulcus establishes this group of tumors as a clinical entity now generally referred to as "Pancoast's" tumor.

Reliable statistical data place cancer of the lung at between 6 and 8 per cent of all cancers. Its correct diagnosis is possible by clinical and laboratory methods in over 80 per cent of the cases. In this diagnosis, particularly in the early stages of the disease, the roentgen examination plays an important part. Untreated, the disease is rapidly fatal. Recent advances in pulmonary surgery have produced a limited number of five year cures, and increasing knowledge of the disease may be expected to improve this percentage. Radiation treatment properly applied in selected cases has given excellent palliative results and in some cases leads to considerable prolongation of life. Furthermore, much of our understanding of the diagnosis and treatment of this disease is of quite recent origin and is constantly being added to. An analysis of the data now available regarding this disease, with some discussion of recent diagnostic and therapeutic advance, would therefore seem to be of value.

I will not burden you with an extended review of the literature, much of which is already out of date, or controversial. Notable exceptions to this statement are the excellent papers of Westermark, on "Roentgen diagnosis," and the recent

* The first Pancoast Lecture, delivered before the Philadelphia Roentgen Ray Society, November 6, 1941.

paper on "Surgical technique and classification" by Churchill and others, but I will base my discussion upon the work of the Thoracic Clinic at the Massachusetts General Hospital during the past decade with which I am personally familiar.

Dr. Ralph Adams of the Surgical Department has recently made a statistical analysis of the cases suffering from primary pulmonary tumors and has kindly allowed me to use his notes in this presentation. The figures given are largely his and may be accepted as free from bias, at least as far as roentgenology is concerned. The statistical review covers the ten year period ending in April, 1940; more recent cases are included in the discussion of methods of radiation treatment. The pathological classification used is that of the Department of Pathology at the Massachusetts General Hospital. It is not new, but has proved quite satisfactory, and with the exception of the classification of certain adenomata as benign tumors, is the one generally accepted.

During the period under discussion a diagnosis of primary carcinoma of the lung was made in 363 cases; this diagnosis was confirmed by microscopic examination in 155 of these cases. The more general use of the bronchoscope and thoracic exploration has increased the number of proved cases in recent years. For the purpose of this discussion only those cases proved by microscopic examination will be used. It is of some interest that during this same ten year period a microscopic diagnosis of sarcoma of the lung was made once and of primary benign tumor seventeen times.

The Department of Pathology has divided the 155 cases of cancer of the lung into four groups—epidermoid carcinoma, adenocarcinoma, "oat-cell" carcinoma, and undifferentiated carcinoma. For clinical or therapeutic purposes the last two may be considered together, leaving three groups, the recognition of which is of considerable clinical importance. In this series 90 cases, or 58 per cent, were epidermoid carcinoma; 23 cases, or 14.5 per cent, were adenocarcinoma; 13 cases, or 8.4 per cent, were undifferentiated carcinoma; and 29 cases, or 18.7 per cent, were "oat-cell" carcinoma. If the last two are considered together the figures would be 41 cases, or 29 per cent; there were no cures in this highly malignant group, but many of them showed excellent palliative results with radiation treatment. Only 27 of the 155 cases were considered operable at the time the diagnosis was made; 15 died following operation before leaving the Hospital, 5 are living and well, apparently free from disease. Both figures are, of course, discouraging, but a more detailed study of the group offers some hope. Delay in arriving at a correct diagnosis was an important factor in the poor results; nearly all of the cases were too far advanced before correct therapeutic procedures were instituted. Better diagnostic procedure, particularly the roentgen examination, and the more general use of the bronchoscope have already corrected this error to some extent. Pneumectomy in advanced cases carries an operative mortality of approximately 50 per cent. Lobectomy, which may be used successfully in early cases, on the other hand, has a rather low percentage of operative mortality, about 5 per cent. When one considers the cases according to the pathological grouping there is still more reason for encouragement. The "oat-cell" and the undifferentiated group are probably incurable from the start, certainly none of them were benefited by surgery, and are better treated by irradiation which gives excellent palliative results. Removal of this group, nearly 30 per cent of all cases, would raise the percentage of operability. Early diagnosis, plus better therapeutic division between irradiation and surgery, should bring about a definite improvement in end-result figures.

The early diagnosis of cancer of the lung, like cancer elsewhere in the body, is dependent upon the patient's seeking advice early. Fortunately, one of the early symptoms of this disease is pulmonary bleeding which usually causes the patient to visit his physician. Too often, however, the physi-

cian does not recognize the seriousness of this symptom, and the proper diagnostic procedures are not carried out. Persistent cough is also an early symptom but of less value in causing the patient to seek advice. Pain in the chest or down the arm, fever and weight loss are symptoms of advanced and usually inoperable disease. In some of our earliest cases there were no symptoms relative to the chest, and the lesion was discovered during a routine chest examination.

The well known fact that the disease is more often seen in males than in females was confirmed in our series, 80 per cent of the patients being males. In the grouping by histological diagnosis the distribution according to sex was more interesting. There were no females in the "oat-cell" carcinoma group, but in the adenocarcinoma group the distribution was about equal.

The duration of symptoms was usually a matter of months rather than years. In those cases giving a history of bronchial obstruction over a long period of time, where a tumor was found, the histopathological diagnosis was usually benign adenoma. Age is of some importance, most of the cases being in the so-called cancer age, but there were several exceptions.

Primary cancer of the lung is clinically and anatomically largely a disease of the bronchi. The signs are those of varying degrees of bronchial obstruction to which may be added the sign of infection beyond the obstruction or that of extension of the malignant process to adjacent lung tissue, the mediastinum, the pleura or nerve root. It is well known that cancer of the lung frequently metastasizes to the brain, and this was a common occurrence in our cases, especially in the adenocarcinoma group.

The roentgen findings vary considerably in the different pathological groupings, and to a much greater extent in the various stages of the disease. Primarily, they are the result of varying degrees of bronchial obstruction in most cases; a noticeable exception being the rounded or lobulated masses sometimes seen at a considerable distance from the hilum when the tumor arises in one of the smaller bronchi. The roentgen appearances of varying degrees of bronchial obstruction was probably first described by Francis Williams of Boston, later your own Willis Manges in a series of papers on the "diagnosis of non-opaque bodies in the respiratory tract" gave us a masterly description of this phenomenon and described in detail the technical procedures necessary to obtain the data on which a correct diagnosis is based. Speaking as I am to a group composed largely of his contemporaries and students, it is unnecessary for me to enter into a detailed discussion of the roentgen findings in bronchial obstruction. I would like, however, to emphasize some of the more important steps in the technical procedures and to discuss in some detail the finding which helps to differentiate the various types of tumor, since upon this differentiation may depend the therapeutic procedure adopted, and the final outcome of the case.

The necessity of a careful roentgenoscopic study of the chest in cases suspected of having a bronchial lesion should be emphasized; too often this part of the examination is neglected or done in a haphazard manner. A properly conducted roentgenoscopic examination gives information difficult or impossible to obtain from the film, such as slight lateral movement of the mediastinum, delayed or irregular movements of the diaphragm on one or both sides, failure of one side of the diaphragm to move during quiet breathing, or abnormalities in the heart beat. It also permits the examiner to study the chest from a greater number of angles and positions than would be practical if films alone were used and, perhaps of the most importance, allows him to so conduct the roentgenographic examination that the greatest possible information will be obtained.

The common practice of taking a pair of stereoscopic films of the chest in the upright position and if these are negative dismissing the patient may be sufficient to

rule out early tuberculosis, but is wholly inadequate in suspected lesions of the bronchi. Such an examination may even result in serious harm to the patient, since it is a frequent cause of delayed treatment. Certainly, all patients in the cancer age group with a history of pulmonary bleeding or symptoms which could possibly be attributed to bronchial obstruction should be given a thorough roentgen examination by a physician skilled in this procedure; at the least it should consist of a roentgenoscopic study and films taken during full inspiration, full expiration, and in the lateral view. When the roentgenoscopic examination shows areas of marked density it is important to take an overexposed film using the Potter-Bucky diaphragm so that a detailed study of these areas may be made. Since the roentgen diagnosis in bronchogenic carcinoma depends almost entirely upon the demonstration of deformity or obstruction of a bronchus, a negative diagnosis should not be made until the outline of the bronchi has been visualized or an unobstructed air flow demonstrated. Usually this information can be obtained by the procedures just described, but it is sometimes necessary to resort to the planigraph or to the injection of opaque substance into the bronchial tree. Bronchoscopy is of great value in the diagnosis of bronchial lesions and should always be used when the roentgen examination shows that the lesion is so situated that it can be reached by this method. It has not, in our experience, been of value in discovering lesions not demonstrated by the roentgen ray except in advanced cases with extensive pulmonary or pleural involvement. It has, on the other hand, been of the greatest value in determining the exact nature of the lesion, namely, the separation of the benign from the malignant lesions, and in determining the type of tumor present. Probably the most common cause of bronchial obstruction in the adult is tuberculosis. Periods of bronchial obstruction also occur in acute respiratory infections, and benign tumors, though not a common cause, occurred sufficiently often in our experience to warrant consideration, especially if there is a history of long duration. Since it is often impossible, from the roentgen examination alone, to determine the exact nature of the obstruction, the wise roentgenologist will usually wait for the histological confirmation of his findings before making a diagnosis of bronchogenic carcinoma. The final outcome in these cases is so grave that it is better to withold the diagnosis until all data obtainable from other sources have been secured. It is sufficient if the roentgenologist states that an obstructing lesion of the bronchi is present and localizes it accurately.

There are certain variations in the roentgen findings which may help to differentiate the various tumors occurring in the bronchi; when for any reason the obtaining of a specimen for histological examination is impossible, these variations become of considerable importance and should be recognized by the roentgenologist.

In the benign adenomata, about 10 per cent of the group studied, we were able, with considerable frequency, to demonstrate a rounded, sometimes pedunculated tumor in the bronchial lumen by using the Potter-Bucky diaphragm, spot films or planigraph. Furthermore, in these cases the hilum and peribronchial glands were not enlarged, at least to the extent seen in malignant tumors, and this tumor does not invade the surrounding lung tissue although it may be accompanied by the secondary inflammatory changes seen in the malignant group. The location of the tumors in the benign group was usually in a main stem bronchus, never in the smaller bronchi. The roentgen signs just enumerated, when accompanied by a characteristic history of repeated attacks of bronchial obstruction over a long period of time, should lead the examiner to a correct diagnosis. Benign adenomata are not differentiated from malignant adenomata in most clinics, and it is our belief that they constitute a considerable percentage of the so-called cures referred to in the literature. In our clinic the end-results of surgical

treatment in this group show 89.2 per cent living and well, while in the group which we have classified as malignant adenomata the survival was only 8.7 per cent. If the pathological classification which we are using is correct, and clinical data so far seem to justify the belief that it is, the recognition of the benign group becomes of the greatest importance. The prognosis under proper treatment is excellent; on the other hand, when improperly treated or neglected the disease tends to run a chronic course and the patient finally succumbs to infection. Irradiation is of little or no value in these cases. Prompt removal of the tumor through the bronchoscope when this is possible, or by surgical excision, is the treatment of choice.

Twenty-three, or 14.6 per cent, of our cases were classified as adenocarcinoma. The outstanding characteristic of this group was the appearance of a tumor mass at varying distances from the primary tumor: either a dense, rounded or lobulated mass close to the affected bronchus seen on the roentgen film, or clinical evidence of metastases in the brain or other distant organ. It is of some interest to note that this type of tumor occurred about as often in the female as in the male, and that it tends to occur at a somewhat earlier age.

Epidermoid carcinoma was by far the most common tumor—58 per cent of all cases; it has no characteristic roentgen finding, usually presenting the classical picture of carcinoma of the bronchus. Clinically this tumor occurred five times as often in males as in females, and a high percentage of cases were in the older age group.

"Oat-cell" carcinoma and undifferentiated carcinoma taken together, as a group, included 29 per cent of our cases, and are of special interest to the radiologist, since many of them respond well to irradiation, and none have been benefited by surgical treatment. The roentgen appearance is that of a rapidly growing tumor which infiltrates surrounding organs. Not infrequently the appearance on the roentgenogram is that of a dense mass with a halo of fine line-like shadows extending into the surrounding tissues resembling somewhat the radiating line seen in some malignant tumors of bone. The signs of bronchial obstruction are often less marked in this group than in other malignant tumors of the bronchi and may be absent. None of the findings, however, are pathognomonic, and the final diagnosis must depend upon the pathological findings.

RADIATION TREATMENT

The more general use of the bronchoscope and of surgical exploration with the opportunity it has given for better diagnosis and for pathological grouping has permitted the radiologist to place radiation treatment on a saner and more logical basis. This, with the extremely penetrating form of radiation now available, should produce better results in radiation treatment of carcinoma of the bronchi.

Although a considerable number of our cases were treated with irradiation, the methods used and the amount and kind of radiation given has varied to such an extent that statistical data are of little value. There are no five year cures, but in many cases relief from distressing symptoms was obtained. Some patients were able to return to work for varying periods of time and in a limited number we believe that life was prolonged. In a few cases where massive doses were given through large fields the progress of the disease seemed to be accelerated. A review of the case histories in the group receiving irradiation has given us valuable information on which a plan of future treatment can be based.

Kind of Radiation Used. In our Clinic we have discontinued the use of radium in carcinoma of the bronchus and are depending entirely upon external irradiation with the roentgen rays. The local application of radium in our experience was attended by so many difficulties and so often resulted in injury to the patient that the slightly greater local effect obtained did not seem to justify its use. Furthermore, it is possible

with supervoltage roentgen rays, now available, to cause a complete disappearance of the primary tumor in selected cases without serious injury to the surrounding tissues. Our experience seems to confirm the generally accepted opinion that heavy irradiation to badly infected tissue is dangerous. Since it is possible to apply an adequate depth dose using a small portal of entry when supervoltage roentgen rays are used, this would seem to be the radiation of choice.

The selection of the cases for irradiation, and the proper planning of the treatment in the individual case is, in our opinion, of considerable importance. If the disease is discovered early, and there is a reasonable chance of cure, we believe that surgery offers the best chance of a five year survival. If this plan is followed the cases selected for irradiation will be those who have already passed the curable stage or for some other reason are considered inoperable. The treatment in the great majority of cases is therefore palliative and nothing should be done which will increase the patient's suffering or shorten the period of useful life. Small doses of properly applied roentgen radiation may relieve pain even in far advanced cases. Rather large doses up to 5,000 or 6,000 r, given through a small field carefully centered over the primary tumor, will often relieve the bronchial obstruction and establish drainage, reducing cough and fever. But in no case is it justifiable to heavily irradiate large areas of infected lung tissues. In selected cases, particularly those with tumors known to be radiosensitive, large fields to include the hilum and mediastinal glands may be used after drainage has been established. In some of these cases a preliminary pneumothorax is helpful. The pathological grouping is of the greatest help in the selection of cases and in the planning of treatment.

The benign adenomata are nearly all curable by surgical means and are known to be radioresistant; they should probably never be subjected to radiation treatment. The malignant adenomata are usually rather resistant tumors and, because of their tendency to form distant metastases early, usually respond poorly, and temporary symptomatic relief is all that can be expected in most cases.

Epidermoid carcinoma often runs a more chronic course and bronchial obstruction with all its attending symptoms is usually present. The tumor, as a rule, is radioresistant, but excellent palliative results have been obtained when the treatment was directed toward relief of the bronchial obstruction and irradiation of infected lung was avoided. Early cases in this group which are poor operative risks or those who refuse operation offer some chance of a five year cure by irradiation.

"Oat-cell" and undifferentiated carcinoma, particularly the former, are radiosensitive tumors and usually disappear rapidly under this form of treatment; symptomatic relief is often complete and for a time the patient seems to be on the road to recovery. But as so often happens with rapidly growing, very malignant tumors, the disease soon reappears, either locally or more often as distant metastases, and the patient rapidly succumbs to the disease. Although there are no cures in this group by any method of treatment, irradiation has given excellent temporary results and should be the method of choice.

Our present plan of treatment, based on these observations, can be briefly stated as follows: Supervoltage roentgen rays are used because with this type of radiation it is possible to give large doses to deep-seated lesions through small portals of entry, and heavy irradiation of large areas of surrounding, often infected tissues, is avoided. Usually the treatment is given through two portals of entry—one front and one back—the lateral field is not used because of the large amount of lung tissue exposed in this plane. The daily dose is small. Roentgen sickness should be avoided. The total dose will depend upon the effect upon the tumor and the reaction of the patient. In cases where an attempt to completely destroy the primary tumor

seems justifiable, the estimated dose at the site of the tumor should be at least 3,000 r. Repeating the treatment after one or more months has elapsed or when a recurrence has taken place, has in our experience, been of little or no value, and in some cases has done more harm than good. Small doses, to relieve pain or to retard the growth of metastases, are distinctly worth while, however.

At this point I would like to present 4 cases which illustrate the diagnostic findings described, and the results obtained with the treatment used.

Case 1 (U–168012). *Adenocarcinoma.* R. B., Jewish housewife, aged forty-six, complained of weakness and general malaise for three years and a dry cough for ten months which became productive three weeks ago. Three days before admission to this Hospital the sputum became blood streaked and she was examined roentgenologically and by bronchoscopy for the first time, although she had been under the general care of a physician and had made frequent visits to a dispensary during the three year period. The roentgen examination suggested bronchogenic carcinoma and the bronchoscopic examination confirmed it. On admission to this hospital the diagnosis was confirmed. The roentgen findings, as well as the clinical picture, are rather typical of adenocarcinoma. Histological examination of a specimen removed at bronchoscopy confirmed this diagnosis. The slides show the characteristic picture—a sharply defined lobulated mass outside the bronchus.

Case 11 (U-178081). *"Oat-cell" Carcinoma.* A. B., an Italian truck-driver, aged forty-nine, entered the Hospital February, 1939, complaining of paroxysmal cough of two months' duration. There was some whitish sputum, but no blood; he also complained of pain beneath the angle of the right scapula. Roentgen examination showed a small mass at the right hilum with evidence of thickening along the interlobar septum and possible interference with the air flow in the right middle lobe bronchus. Bronchoscopy confirmed these findings and showed a tumor mass protruding into the lumen of the bronchus. A specimen was taken which, on examination, showed the tumor to be carcinoma of the "oat-cell" type.

Roentgen treatment was advised and given over a period of about one month, the last treatment being April 28, 1939. Two hundred kilovolts with 50 cm. distance was used, the treatment given through four portals centered over the tumor mass; the size and position of the fields were determined by roentgenoscopy and as far as possible were confined to the mass. Each field received 2,400 r, measured in air. Improvement was prompt and an examination in June, five weeks after beginning treatment, showed disappearance of the tumor and at this time the patient was symptom-free.

He continued well until February, 1941, nearly two years after beginning treatment, when he had a severe shaking chill and was very sick for four days, after which he slowly improved but did not recover completely. Fever continued and cough became severe, at times the sputum contained blood. He was again admitted to the Hospital. The roentgen examination showed a collapse of the right middle lobe, and bronchoscopy showed a tumor mass in the middle lobe bronchus. It was thought that the symptoms were due to plugging of the bronchus with infection behind the plug. Another series of roentgen treatments was started in the hope of relieving the obstruction. The same voltage, filtration and distance as in the previous treatment was used, and 2,000 r was given through three 10 by 10 cm. fields, directed toward the tumor mass. Again the response to treatment was prompt, his temperature returned to normal, the cough became less severe and he gained weight. The appearance in the chest, however, did not return to normal, and another course of treatments was given in August using the 1,000 kv. machine. He continued comfortable until January, 1941, when the symptoms of cough, bloody sputum, chills and fever again appeared. After considerable discussion it was decided to again try roentgen treatment; this series of treatments gave only partial relief. The patient failed slowly and died July, 1941, two and a half years after beginning treatment.

At autopsy a carcinoma, "oat-cell" type, of the right lung with metastases to the mediastinum, bronchial and retroperitoneal lymph nodes, the mesentery, liver, pericardium, brain and skin was found. The right lung was collapsed, showed extensive tumor infiltration and there was a large amount of pus in the right pleural space. The tumor was active at its original site. This patient showed the characteristic response to irradiation so often seen with this type of tumor, and certainly received

considerable benefit from the treatment. The treatment given in the latter part of his illness was of no avail, and probably should not have been given. In this group metastases take place early and are widespread. All the patients have eventually died.

Case III (U-52014). *Benign Adenoma.* R. MacA. This housewife, aged thirty-nine, gave a history of cough and "repeated colds" of ten years' duration; the sputum was scanty and of a whitish color. She had had one rather severe hemorrhage; there was no weight loss. The roentgen examination showed a collapse of the right lower lobe with bronchiectasis; and a rounded tumor mass could be demonstrated in the bronchus leading to the right lower lobe. Bronchoscopy confirmed the roentgen findings. Treatment was carried out by the bronchoscopist and the patient received complete symptomatic relief. Six years later she returned to the Hospital with signs of large bowel obstruction. An inoperable adenocarcinoma of the colon was found from which the patient died.

Autopsy showed a complete collapse of the right lower and middle lobes; these lobes were airless and not infected. The upper lobe filled almost the entire right pleural space. In the right stem bronchus just beyond the orifice of the upper lobe bronchus, a firm rounded mass, 3.0 cm. in diameter, was found. Histopathological examination of the mass confirmed the diagnosis of benign adenoma.

Case IV (U-278307). *Epidermoid Carcinoma.* R. E. L., a teamster, aged fifty-six, was admitted to the Hospital November 29, 1940, with a history of cough, dyspnea, weakness and fatigue of four months' duration. Slight exertion, or lying on his right side would bring on an attack of severe dyspnea, accompanied by marked distention of the veins of the neck with swelling of the neck and face. The cough was severe and productive. There was no blood. His temperature was not elevated, but he did have night sweats.

Roentgen examination showed collapse of the right upper lobe, thickening of the interlobar septum, enlarged hilar glands and blocking of the right upper lobe bronchus.

Bronchoscopy confirmed the roentgen findings, and a piece of tissue removed at this examination showed epidermoid carcinoma. Roentgen treatment was advised, and was followed by considerable improvement. The patient returned to work, but the appearance in the lungs was unchanged and at the present time the mass is increasing slowly. The treatment used was 1,200 kv., 2 mm. Pb, 5 mm. Cu, 70 cm. distance, two fields, 15 by 15 cm., one front and one back centered over the junction of the right stem and upper lobe bronchi; 3,000 r, measured in air, was given to each field; the daily dose was 300 r.

In this case the collapse of the right upper lobe was complete and there was little or no infection. The symptoms were probably due largely to mediastinal involvement and were relieved by the treatment which had no effect on the collapsed lung.

I have tried to present for your consideration a few facts with some observations and impressions which can be summarized briefly as follows:

The early diagnosis of pulmonary tumors is largely a roentgenological problem. In assuming this responsibility the roentgenologist must make certain that the technical procedure which he uses even in routine examination of the chest is adequate to demonstrate an early bronchial lesion.

It is of some importance to determine the type of tumor present since the treatment selected is to a considerable extent dependent upon the histopathology of the tumor.

The recognition of benign adenoma is of special importance since nearly all of these cases are curable by surgical means.

Treatment by irradiation gives the best palliative results in the "oat-cell" and other highly malignant tumors, and at the present time should be the method of choice. In these cases irradiation of large areas should be avoided especially before bronchial drainage has been established.

In large radiosensitive tumors the daily dose, especially in the early stages of this treatment, should not be too large.

A better understanding of modern methods of diagnosis and treatment should lead to better end-results in the management of pulmonary tumors. The situation is by no means hopeless.

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LYMPHOSARCOMA

WITH SPECIAL REFERENCE TO THE RETICULUM-CELL TYPE*

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KUNDRAT in 1893 was the first to separate the condition known as lymphosarcoma from the general group of the lymphomas. He described the disease as a widespread growth arising from a chain of lymph nodes, rarely from one node, and found in the lymphoid tissues of the pharynx, intestinal wall, etc.

The early systemic character of the disease is usually negligible. There is seldom extensive involvement of the spleen marrow and liver similar to that found in leukemia, pseudoleukemia, or Hodgkin's disease. However, the usual lesion is a rapidly invasive growth extending through the capsules of the lymph nodes into the surrounding tissue. Kundrat believed that distant metastases were rather rare, but that secondary tumors occurred in the intestinal mucosa, serous membrane, and other lymph nodes by direct extension through contiguous lymph channels. Ewing[1] believes that extension takes place exclusively by way of the lymphatics during earlier stages of the disease, although true metastatic growths appear in the lungs, brain, kidneys, skin, and other organs in advanced cases. He states that the lesions may first appear either as a localized or as a diffuse process. The subsequent course tends to be more malignant in the localized type. The disease tends to attack robust males and the usual age range reported in the literature is from twenty-five to fifty-five years.

The ultimate prognosis of lymphosarcoma patients is hopeless as to normal life expectancy. According to Ewing,[1] the duration of the disease varies widely, although the usual course is progressively fatal within a few months. Wide extensions are observed chiefly with a more prolonged course. After local treatment, extirpation, internal use of arsenic, or the application of roentgen irradiation, the disease often appears to be arrested only to reappear after a brief period.

From 1929 to 1941 twenty proved cases of lymphosarcoma received roentgen therapy at St. Luke's Hospital, Chicago, Illinois. Sixteen of these have been followed or have since died. It has been impossible to obtain a complete follow-up on the other four. An accurate evaluation of the response of lymphosarcoma patients to irradiation is sometimes attended by difficulty in diagnosis and classification. MacCallum[2] in his recent book states that it is often difficult to distinguish lymphosarcoma from other lymphomas and from the study of a single section it would probably be impossible to distinguish the cells from those of chronic lymphoid leukemia, leukosarcoma, lymphosarcoma, and round-cell sarcoma. He states that lymphosarcoma is an invasive growth with regional spread often limited to the thorax and abdomen. It should be noted, however, that several advanced cases in this series had widespread lesions including involvement of the bones. Ewing's[1] classification of lymphosarcoma was used in this series. He states that two specific cells participate in the origin of lymphosarcoma, giving rise to two separate specific forms of tumors. These cells are (1) lymphocytes, and (2) reticulum cells of the germ centers of follicles and pulp cords. The two types of lymphosarcoma are then designated as (1) malignant lymphocytoma, and (2) reticulum-cell lymphosarcoma. In the present series there were biopsies on all patients and a microscopic diagnosis of lymphosarcoma established by competent pathologists. An attempt was made to divide the series of 16 patients into two groups, depending upon the predominating cells,

* Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

FIG. 1. Case 1. June 26, 1936. Before irradiation.

realizing that any arbitrary classification is difficult and must be made to accommodate occasional borderline cases.

CLINICAL MATERIAL

From the group of 20 proved lymphosarcoma cases, this series to be presented includes only the 16 in which an adequate follow-up could be obtained. There were 8 classified as malignant lymphocytomas and 8 as reticulum-cell lymphosarcomas. There were 11 males and 5 females. The age of onset ranged from seven to sixty-three years, with an average age of forty-two.

Case 1 is representative of the group of malignant lymphocytomas.

CASE 1. A white male, aged forty-eight, entered the Hospital on June 24, 1936, complaining of dyspnea, orthopnea, thoracic pain, weakness, and loss of weight. There was a history of pleurisy and a right hydrothorax eight months previously. Physical examination at the time of entrance revealed cervical and axillary adenopathy and a right hydrothorax. The diagnosis was made from biopsy of the cervical and axillary adenopathy approximately eight months after the onset of chest symptoms. This patient has received six series of roentgen therapy to six general body regions for a total of 10,745 r over a period of five years, using 200 kv. (peak), Thoraeus filter (equivalent to 1 mm. Cu), and 50 cm. distance. The excellent response to irradiation of the chest is demonstrated in Figures 1 and 2 (also Figs. 3 and 4, Case 11).

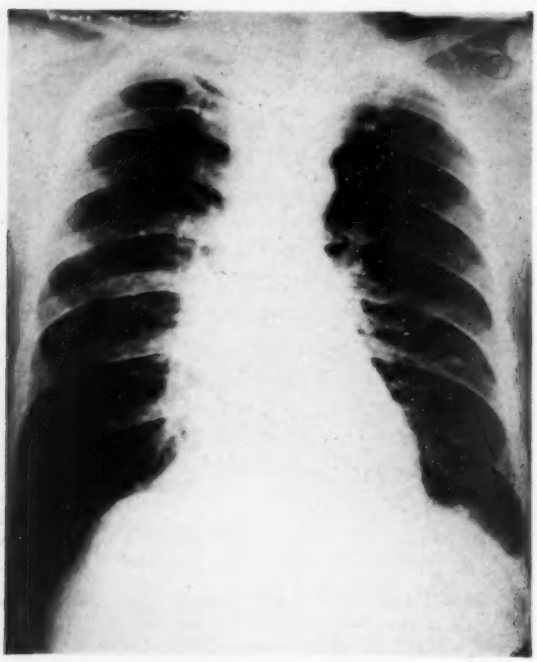

FIG. 2. Case 1. December 29, 1938. After irradiation.

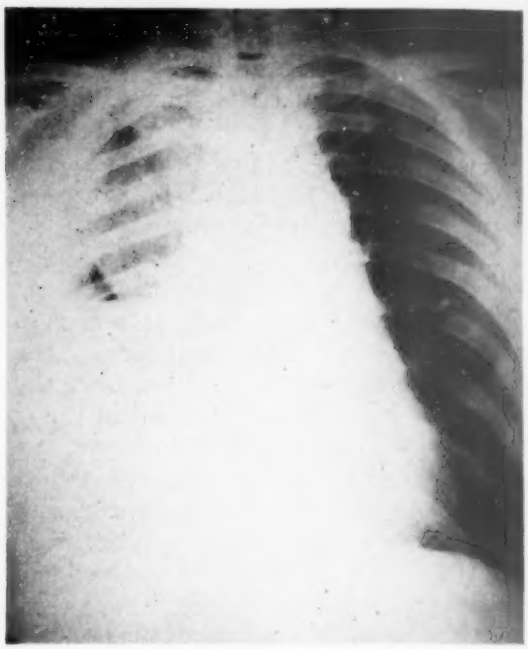

FIG. 3. Case 11. April 20, 1936. Before irradiation.

This patient is living and feeling well at the present time, approximately five and a half years after the onset of the first symptoms of the disease.

The reticulum-cell lymphosarcoma group is illustrated by Case III.

Case III. A white male, aged twenty-seven, entered the Hospital on April 23, 1940, complaining of progressive enlargement of the cervical lymph nodes during the previous month, a slight cough, and loss of 10 pounds in weight. Physical examination revealed bilateral cervical

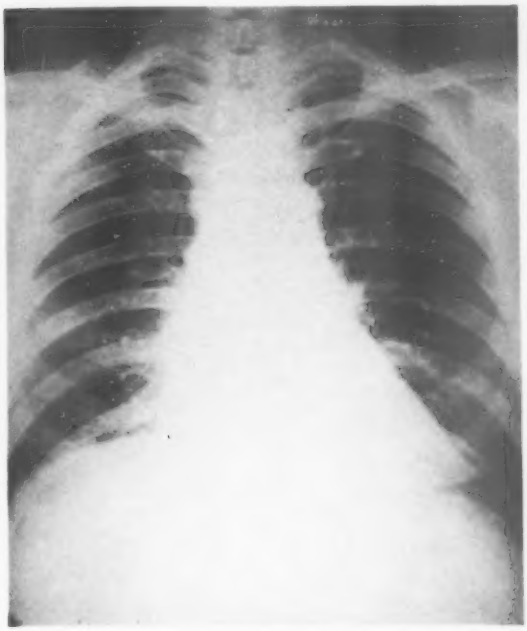

Fig. 4. Case II. September 3, 1940, After irradiation.

and supraclavicular adenopathy. There were no unusual chest findings. Biopsy of the cervical lymph nodes revealed a reticulum-cell lymphosarcoma. Immediate roentgen therapy was initiated. He received eight series to eight general body regions for a total of 20,619 r over a period of thirteen months. Despite extensive and almost continuous therapy, the patient's condition became progressively worse, and terminated in death approximately fifteen months after the onset of the first symptoms of the disease. The unfavorable response to irradiation of the chest is demonstrated by Figures 5 and 6. The autopsy findings included a generalized lymphosarcoma of the cervical, axillary, tracheobronchial, periaortic, biliary,

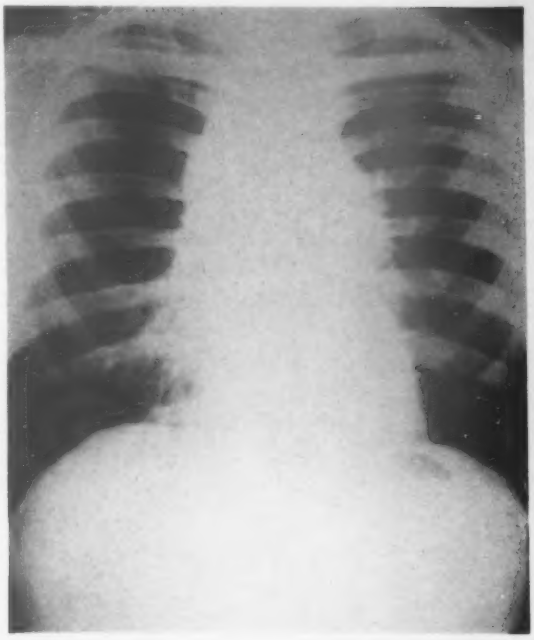

Fig. 5. Case III. May 14, 1940. Before irradiation.

mesenteric, and splenic lymph nodes; lymphosarcoma metastases of the spleen, liver, ileum, mediastinum, lungs, subpleural tissues, bronchi, and left kidney; anasarca; bilateral serofibrinous

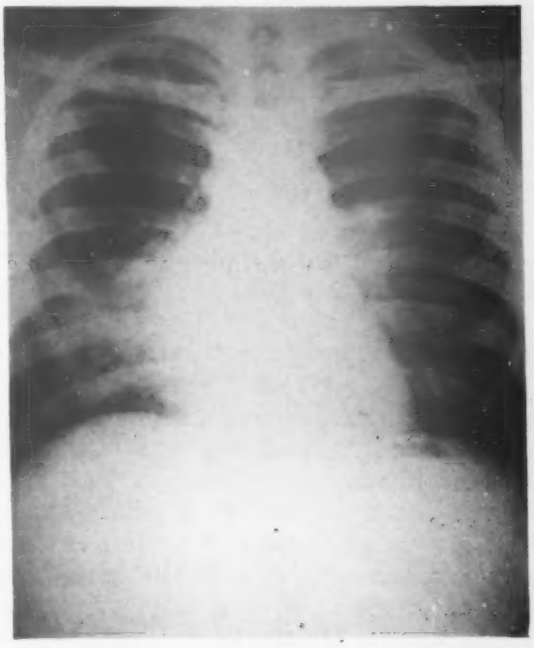

Fig. 6. Case III. November 25, 1940. After irradiation.

pleuritis; slight ascites; and hypostatic edema of the lungs.

The presence of metastatic lesions in this patient and in others of this series confirms Ewing's[1] statement that true metastatic spread may occur in late stages of the disease.

A summary of all patients in both groups is given in Tables I and II.

COMMENT

From Table I it is apparent that the malignant lymphocytoma group responded more favorably to irradiation than did the reticulum-cell type. The average duration of life after onset of the disease in the lymphocytoma group was forty-eight months, or four years. Of these 8 patients there were only 2 who lived less than two years. One of these, Case VIII, had a widespread mesoblastic growth when the diagnosis was made and his critical condition prevented adequate radiation therapy. The other patient, Case XII, was a child, aged seven, who had a good response from only two treatments but refused to continue therapy. The other 6 patients in this group lived from two to eight years after the onset of the disease. This is more significant when it is noted that the initial lesion in 4 of the group was apparently in the mediastinum, and in 3 others in the abdomen, so that diagnosis was delayed until considerable extension of the disease manifested its true nature. In this group there was an average lapse of six months between the onset of the first symptoms of the disease and the institution of the roentgen therapy.

In the reticulum-cell group (Table II) the response to radiation therapy was less favorable. The average duration of life after the onset of the disease was twenty-four months, or two years. However, there are only 2 in this group, who, thus far, have lived more than fifteen months after the onset of the first symptoms. The average of the group is raised by the inclusion of Case V. The classification of this case is on the basis of a biopsy taken approximately six years after the onset of lymphadenopathy and may be questionable in that certain characteristics of the tissue were not unlike a follicular lymphoblastoma. However, the presence of mitotic reticulum

TABLE I

MALIGNANT LYMPHOCYTOMA

Case No.	Sex	Age at Onset of First Symptom	Site of Initial Lesion	Duration of Life in Months after Onset	Present Status	Number of Months between Onset and Initial Therapy	Number of Series	Number of Regions	Total Roentgens	Clinical Response
I	M	48	Mediastinum	68 plus	Good	8	6	3	10,745	Good
II	M	59	Mediastinum	54	Dead	1	2	4	7,170	Good
VIII	M	63	Mediastinum	7	Dead	3	2	1	1,956	Temporary
XI	F	59	Mediastinum	24	Dead	8	3	3	12,800	Good
XII	M	7	Cervical	4	Dead	1	1	1	560	Good
XIII*	F	46	Abdominal	96	Dead	2	6+	5+	7,640	Good
XIV*	M	24	Abdominal	96	Dead	4	3+	3+	11,910	Good
XV	M	57	Abdominal	36	Dead	24	2	2	9,858	Good
		(years)								
	6M	Range	Mediastinum 4	4–96	Living 1	Average 6				
	2F	7 to 63	Cervical 1	Average 48	Dead 7					
		Average 45	Abdominal 3							
			8							

* Cases XIII and XIV also received therapy elsewhere and data are not available.

cells and considerable stroma was taken as sufficient evidence that the disease at the time of biopsy was a reticulum-cell type of lymphosarcoma.

Except for the response to roentgen therapy, there is no apparent contrast between the two groups. There was a preponderance of males in both groups. The age range was similar, although the average age was slightly lower in the reticulum-cell group. In 5 of the reticulum-cell group the initial lesion was superficial, so that early therapy undoubtedly prolongs the patient's life. This is especially true of the malignant lymphocytoma variety and substantiates Boyd's[3] statement that the distinction between the two varieties is of clinical importance because the lymphocyte type responds readily for a time to irradiation, while the reticulum-cell type is much more resistant. The majority of this group of malignant lymphocytomas were relatively free from symptoms for a number of years and were able to carry on their usual activi-

TABLE II

RETICULUM-CELL LYMPHOSARCOMA

Case No.	Sex	Age at Onset of First Symptom	Site of Initial Lesion	Duration of Life in Months after Onset	Present Status	Number of Months between Onset and Initial Therapy	Number of Series	Number of Regions	Total Roentgens	Clinical Response
III	M	27	Cervical	15 plus	Dead	1	8	8	20,619	Poor
IV	F	56	Groin	48 plus	Good	1	4	4	5,550	Good
V*	M	41	Cervical	06 plus	Good	1	4+	5+	4,976	Good
VI	M	55	Cervical	7 plus	Good	1	4	3	4,052	Good
VII	F	8	Groin	11	Dead	2	5	5	6,060	Temporary
IX	M	19	Mediastinum	7	Dead	3	3	2	6,390	Temporary
X	F	40	Nasopharynx	8 plus	Good	3	1	1	6,800	Good
XVI	M	60	Abdominal	2	Dead	1	1	1	400	Poor
		(years)								
	5M	Range	Cervical 3	2–96	Living 4	Average 2				
	3F	8 to 60	Groin 2	Average 24	Dead 4					
		Average 39	Abdominal 1							
			Nasopharynx 1							
			Mediastinum 1							
			8							

* Case V also received therapy elsewhere and data are not available.

diagnosis was possible. There was an average lapse of about two months between the onset of the disease and the institution of radiation therapy in this group. Despite this, the response was less favorable than in the malignant lymphocytoma group where there were extensive lesions before therapy was instituted.

DISCUSSION

In comparing the results in this series of lymphosarcoma patients with Ewing's[1] statement as to the usual duration of the disease, it is apparent that roentgen therapy undoubtedly prolongs the patient's life. This is especially true of the malignant lymphocytoma variety and substantiates Boyd's[3] statement that the distinction between the two varieties is of clinical importance because the lymphocyte type responds readily for a time to irradiation, while the reticulum-cell type is much more resistant. The majority of this group of malignant lymphocytomas were relatively free from symptoms for a number of years and were able to carry on their usual activities. The reticulum-cell group, on the other hand, tended to have a more malignant course, although there was frequently a temporarily favorable response to the therapy. Despite some remission of symptoms, there was usually a progressive increase and extension of the lesions. There is no apparent explanation for the difference in radiosensitivity of the two groups other than the inherent characteristics of the cell types. The principal factor is probably the high degree of cellularity and scanty stroma of the malignant lymphocytoma as compared with the relatively greater amount of

fibrous stroma and fewer cells in the reticulum-cell lymphosarcoma.

SUMMARY

Sixteen proved cases of lymphosarcoma were treated with roentgen irradiation. Eight of these had a diagnosis of malignant lymphocytoma; the other eight a diagnosis of reticulum-cell lymphosarcoma. The average duration of life after the onset of the first symptoms of the disease in the lymphocytoma group was about four years as compared with the average duration of approximately two years in the reticulum-cell lymphosarcoma group. Roentgen therapy was beneficial to both groups in that there was a variable remission of symptoms allowing the majority of patients to carry on their usual activities for a longer period of time.

REFERENCES

1. Ewing, James. Neoplastic Diseases. Fourth edition. W. B. Saunders Co., Philadelphia, 1940.
2. MacCallum, W. G. A Textbook of Pathology. Seventh edition. W. B. Saunders Co., Philadelphia, 1940.
3. Boyd, William. A Textbook of Pathology. Second edition. Lea & Febiger, Philadelphia, 1934.

DISCUSSION

Dr. U. V. Portmann, Cleveland, Ohio. Drs. Jenkinson, Kinzer and Brown have brought up a controversial subject. Not all pathologists agree about the histogenesis of malignant neoplasms which they call lymphosarcomas and reticulum-cell sarcomas, nor can they always distinguish between these types from histopathology alone. Likewise, radiologists have difficulty in correlating or evaluating clinical manifestations and response to irradiation of tumors described or named lymphosarcomas, or reticulum-cell sarcomas by pathologists.

The histogenesis of "lymphoid" neoplasms is as complex and confusing as their morphology. Medical literature does not clarify the matter satisfactorily. The authors have chosen to base their observations of variations in response of two types of lymphosarcoma, classified as malignant lymphocytoma and reticulum-cell sarcoma by Ewing. As I understand this scheme one type is supposed to originate from primitive cells or lymphoblasts in the germinal center of lymph nodes; therefore it is called "reticulum-cell sarcoma." The other type is supposed to arise from more differentiated cells or lymphocytes outside of the germinal centers of lymph nodes; therefore it is called "malignant lymphocytoma." But there may be other possibilities.

Reticulum cells are present not only in the germinal cells but also in the stroma of lymph nodes, in fact they are distributed abundantly in all tissues. Reticulum cells are primitive cells derived from mesenchyme. They are more primitive and less specialized than their offspring lymphoblasts and lymphocytes. They are thought to be the progenitors of many kinds of stroma cells. Under certain circumstances, such as the presence of inflammation, reticulum cells in any part of the organism may proliferate and differentiate forming into lymphoid structure.

Malignant neoplasia may begin in any cells of any tissues or at any stage in their cycle of cellular differentiation from primitive to more adult or specialized types. This may happen to reticulum cells whether in the germinal centers or stroma of primary lymph nodes, in lymphoid structures developed elsewhere or those in any kind of connective tissue; as, for example, in fat. The resultant tumor would be a reticulum-cell sarcoma. Likewise, if and when malignant neoplasia begins in the more specialized lymphocytes, whether in primary lymph nodes or lymphoid tissue elsewhere, which may have developed from reticulum cells, then the resultant tumor may be called a malignant lymphocytoma.

This concept of the differences and similarities in histogenesis of malignant lymphocytoma and reticulum-cell sarcomas explains why they are not structurally homogeneous, but heterogeneous as to cell types. They are composed of reticulum cells, lymphoblasts, lymphocytes and stroma in varying proportions in different tumors, different parts of the same tumor, in tumors primary in different or the same anatomical locations whether originating in primary lymph nodes or elsewhere. Therefore, in applying a name descriptive of a particular lymphosarcoma, it is identified principally according to the predominating cell type as malignant lymphocytoma or reticulum-cell sarcoma. This variation in structure is not characteristic of lymphosarcomas alone but is present also in most other malignant neoplasms, as for example carcinomas.

The differences in histogenesis not only ex-

plain why pathologists have difficulty in identifying different types of tumors originating from reticulum cells or lymphocytes, but also why there are no pathognomonic clinical signs or symptoms of differential diagnostic significance. No matter whether these tumors originate in reticulum cells, lymphoblasts or lymphocytes, they have symptomatic and physical features in common.

Now the authors find differences in the response to irradiation of what they call malignant lymphocytomas and reticulum-cell sarcomas. They explain it on the basis of greater proportions of radioresistant stroma in reticulum-cell sarcomas. This may be the answer because these tumors do have more stroma than malignant lymphocytomas; in fact, reticulum cells are primitive stroma cells. But I have been under the clinical impression that malignant lymphocytomas also vary in their response to irradiation irrespective of their primary anatomical location.

After irradiation most lymphosarcomas of any primary origin decrease in size, occasionally they disappear, some recur locally, others metastasize or secondary tumors develop. However, there can be no doubt that a majority of patients are benefited by irradiation and many lives are prolonged.

The question which the authors have presented so well is timely and should be given consideration and further investigation.

THE VALUE OF THE ROENTGEN THERAPEUTIC TEST DOSE IN DIFFERENTIAL DIAGNOSIS OF MEDIASTINAL TUMORS*

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PERHAPS in no other medical domain can differential diagnosis be as difficult as in mediastinal tumors. Various roentgen procedures such as roentgenoscopy, roentgenography under different angles, kymography and more recently laminagraphy, permit exact morphologic and even topographic evaluation in most cases, but the precise nature of the tumor is determined rarely. The problem is further complicated by the fact that the mediastinum contains structures giving rise to a comparatively great variety of neoplasms.

For nearly two decades attempts have been made to apply the so-called "roentgen therapeutic test dose" for the purpose of differentiation. This means that the largest amount of radiation is given over the chest that can be tolerated without producing injury to the normal structures, especially the lungs. Its administration has a double aim: (*a*) to act as a therapeutic agent in case the tumor is radioresponsive, and (*b*) to constitute a test of radiosensitivity when there are no other possibilities for differential diagnosis.

The method, however, has found limited use. It was felt that since in the largest majority of instances mediastinal tumors represent hopeless conditions, a correct diagnosis is eventually established by more exacting means as, for example, study of the subsequent clinical course, biopsy of some distant extension or by postmortem examination. On the other hand, the rapid development in the technique of thoracic surgery has made possible an approach of the problem along lines which are customary in the more accessible tumor regions. Thus when radiation therapy was decided upon, this was recommended as a last resort merely for palliation.

A review of 73 cases of mediastinal tumor treated at Harper Hospital from 1922 to 1936 inclusive (Table 1), by the application of the roentgen therapeutic test dose first and correspondingly adjusted doses thereafter, has brought to light some interesting observations, which, in our opinion, justify a re-study of the entire problem. It is the purpose of the present paper to consider the various factors which permit a differentiation and to give on the basis of coordination of the immediate irradiation response with the late results a practical arbitrary grouping of all mediastinal tumors, thus arriving at certain definite conclusions concerning the clinical value of the method as a whole.

TECHNIQUE OF PROCEDURE

Since, as already stated, the roentgen therapeutic test dose in most instances represents the maximum amount of radiation that can be safely administered, its exact measurement is of the utmost importance. Animal experiments and repeated clinical observations have proved beyond doubt that if a dose exceeding 150 per cent skin unit dose is given over the lungs in one single series, irreparable fibrosis of the lungs follows. If the irradiation is repeated with smaller doses or protracted over a longer period of time, the danger of producing permanent damage is even greater. The chief reason for this is the fact that it is exceedingly difficult to properly evaluate a roentgen biologic effect over a longer period of time, no matter how accurate the individual physical doses might have been.

* Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

Therefore in administering the roentgen therapeutic test dose, our aim must be to deliver to the tumor area the entire radiation within the shortest possible time. Only when the patient is so extremely cyanotic that oxygen inhalation has to be resorted to is the roentgen therapy carried out with the divided, protracted method over a period of several weeks.

During the course of time, it was found that 130 per cent S.U.D.* represents the uppermost limit of a roentgen therapeutic test dose which may be administered safely in the average case. This is given by cross-firing the tumor through several portals according to the individual requirements. One portal is treated daily with a full skin unit dose per seance, so that the series is completed in two to six days. If the fractionated, protracted method is used, the irradiation is carried out in successive rotating cycles. The total accumulated dose again is brought up to 130 per cent S.U.D. on the tumor, due allowance being made for the daily radiation loss which, if the irradiation is extended over a period of

TABLE I

TOTAL NUMBER AND CLASSIFICATION OF MEDIASTINAL TUMORS ON WHICH ROENTGEN THERAPEUTIC TEST DOSE WAS APPLIED AT HARPER HOSPITAL BETWEEN 1922 AND 1936, INCLUSIVE

Year	Group I		Group II		Group III			Group IV				Unclassified	Total
	Lymphocytoma	Aleukemic or Lymphatic Leukemia	Hodgkin's Disease	Reticulum- or Spindle-Cell Sarcoma; Endothelioma	Carcinoma of Thymus	Other Carcinoma	Fibrosarcoma	Dermoid	Neuroganglioma	Other Benign Tumors	Aneurysm		
1922					1	1	1					1	4
1923	1						1						2
1924		1	1		1		1				1		5
1925			1				1			1			3
1926	1		2	1			1		1				6
1927	1						1					2	4
1928			1	1				1				1	4
1929		1	1		1	1	2		1			1	8
1930	1						2			1		1	5
1931	1	2	2				1						6
1932			1							1	1		3
1933		1	1		1	1							4
1934	1		2									1	4
1935	1	2				1		1	1	1	1	1	9
1936	1		2				1	1			1		6
Total	8	7	14	2	4	4	12	3	3	4	4	8	73
Alive 5 years	2		5				1	2	3	4			17

In addition, 26 cases were subjected to the roentgen therapeutic test dose which eventually proved to be inflammatory conditions, mostly tuberculous lymphadenitis.

* One hundred per cent S.U.D. represents 900 r (525 r in air) given in one seance on a field 20 by 20 cm. with an intensity of 20 r per minute, if the quality of the roentgen rays is that obtained with 200 kv. equiv. (1 mm. Cu); and 1,100 r (800 r in air) if the quality is that obtained with 500 kv. equiv. (7 mm. Cu).

several weeks, is taken as an average of 7 per cent. In this latter instance, oxygen inhalation is often applied with a portable apparatus during the treatment. If the breathing becomes labored in the extreme, the initial fractions of the roentgen rays are made small so as to entirely avoid superimposed edema from the irradiation effect. They are, then, increased at subsequent seances according to the tolerance of the patient.

When periodical checkup examinations reveal a good response of the mediastinal tumors and repetition of the irradiation, for one or several series, is necessary, exceedingly great care must be taken in outlining the treatment for these additional series. Unless a fibrosis of part of the lung or of an entire hemithorax is outrightly desired (Fig. 10 and 16) the cross-firing must be done with as small and as few portals as possible to avoid a re-irradiation of too large a portion of the surrounding normal lung. In this respect, it is advisable to gradually reduce the portals also during the latter part of a fractionated, protracted irradiation series, when it is found that the tumor regresses at such a rate that a narrowing of the portals becomes possible. A repetition of such irradiation is undertaken rarely.

The quality of the roentgen rays employed for the therapeutic test dose was first that obtained with 200 kv. and 1 mm. Cu forefilter. Since 1932, however, supervoltage roentgen rays obtained with 500 kv. and 7 mm. Cu forefilter were preferably used. The chief reason of this lies in the fact that because of the greater depth dose, the latter permits a more efficient cross-firing of the tumor with less risk of injury to the normal structures.

VARIATION IN IRRADIATION RESPONSE

It is now generally recognized that the radiosensitivity of a certain tumor depends, among other things, on its cellular characteristics. For this reason, under given circumstances certain deductions may be drawn from the degree of radiosensitivity as to the nature of the tumor.

The mediastinal neoplasms, as a whole, originate from tissues giving rise to such a great variety of cellular elements that nearly the entire scale of radiosensitivity is encountered. At the top there is the extremely radiosensitive lymphocyte with all its typical and atypical cell proliferative processes, such as lymphocytoma, aleukemic leukemia or pseudoleukemia, lymphatic leukemia, thymoma, etc.; at the bottom the group of fully matured, radioresistant benign tumors as, for example, chondroma, neuroganglioma or dermoids. Between these two extremes lies an array of cell components of intermediary radiosensitivity. The rather frequent mediastinal Hodgkin's disease and a few of the sarcomas, such as reticulum-cell sarcoma, spindle-cell sarcoma, etc., occupy a position nearer the top, whereas the carcinomas of the thyroid and thymus, the fibrosarcoma, melanosarcoma, etc., are closer to the bottom.

Obviously an accurate differentiation of all these tumors on the basis of periodical observations of their irradiation response alone is impossible. But under certain circumstances and by making use of all clinical criteria of diagnosis, the application of the roentgen therapeutic test dose may lead to such valuable information that the true nature of the tumor is finally established. In our series, a correct diagnosis was eventually made in more than 90 per cent of the cases. Moreover, and this fact is perhaps even more important, an approximate differential diagnosis was established at a time when the choice of the subsequent therapeutic procedures was of greatest interest.

The periodical checkup roentgenograms of the chest are made at intervals of two weeks, six weeks, three months, etc., counting from the day of completion of the irradiation series. The rate of regression is expressed in percentage of the original size of the tumor.

CLASSIFICATION

On the basis of the irradiation response, it is possible to place, for all practical pur-

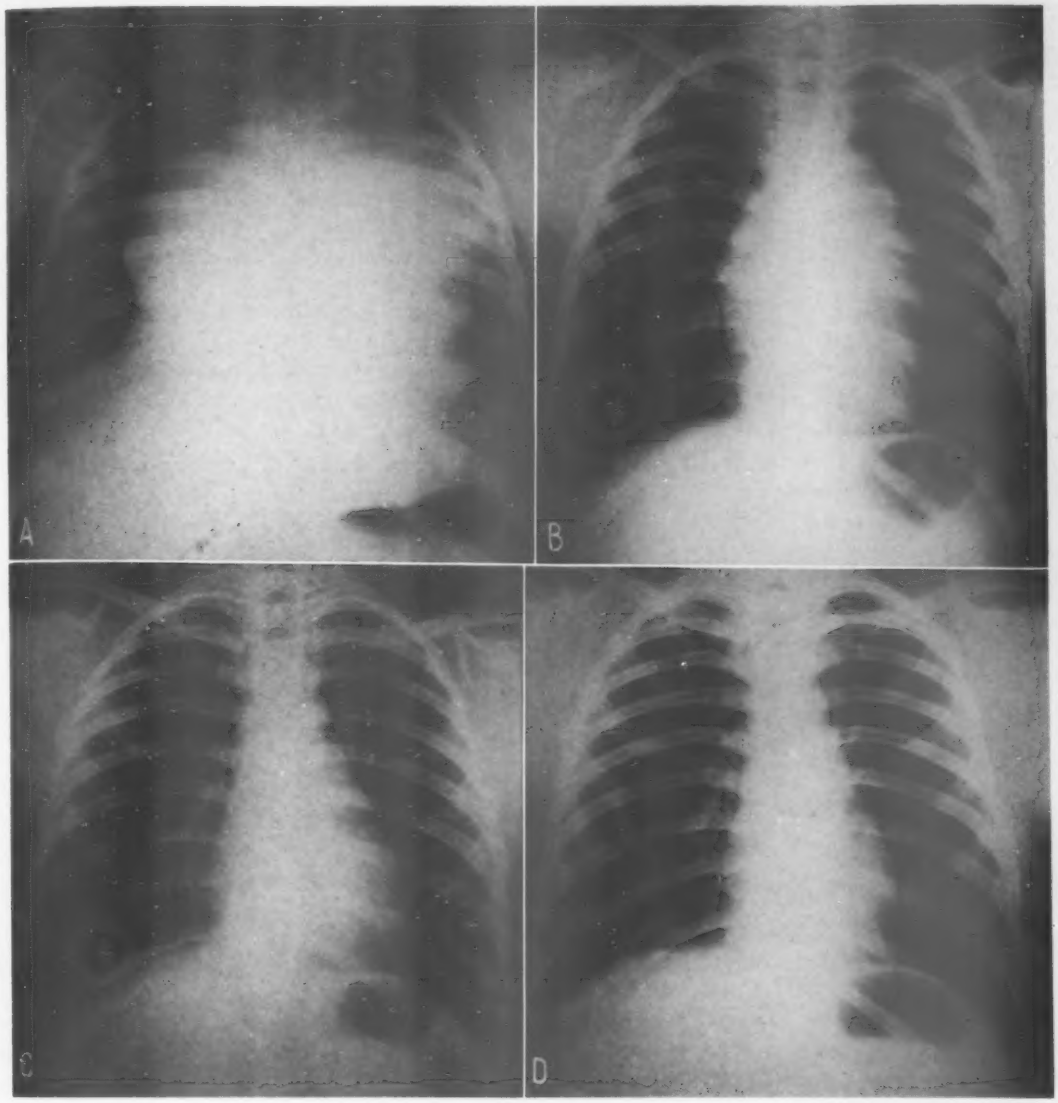

Fig. 1. Case 1. Lymphosarcoma. *A*, before treatment; *B*, two weeks later; *C*, one month later; *D*, five years later. Patient is well.

poses, the mediastinal tumors into four rather arbitrary groups.

Group I. Tumors originating from the proliferation of the highly radiosensitive lymphocytic cell element, such as lymphocytoma; mediastinal manifestations of aleukemic leukemia, pseudoleukemia and lymphatic leukemia; and lymphosarcoma of the thymic gland.

The regression of these tumors following the administration of the roentgen therapeutic test dose is spectacular. They completely "melt away" within two or three weeks after treatment.

Three examples are cited for the purpose of illustration.

Case 1. E. V., male, aged eighteen. In October, 1936, the patient noted that he became short of breath on exertion. He also developed fatigue and gradual weakness. In November, he started to have a dry hacking cough. All of these symptoms gradually increased so that by the middle of January, 1937, the patient was confined to bed.

1-10-37: Examination revealed a very marked cyanosis with extreme shortness of breath. There was a marked puffiness of the neck and face with engorgement of the superficial veins

such as observed secondary to pressure effect in the mediastinum. There was also a slight enlargement of the liver.

A roentgenogram of the chest demonstrated a huge mediastinal tumor measuring 22 cm. crosswise in its greatest diameter (Fig. 1).

1-10-37 to 2-9-37: Therapeutic test dose was given over the mediastinum amounting to 130 per cent S.U.D. with 500 kv., 7 mm. Cu. On account of the marked cyanosis, oxygen had to be applied during the course of irradiation, which was carried out in fractions.

2-24-37: Roentgenogram of the chest showed marked regression of the tumor.

3-8-37: Mediastinum appeared normal in size.

fatigue with occasional dry, hacking cough. This was attributed to a chronic bronchitis. In July, 1934, he became progressively short of breath.

8-14-34: Examination revealed an extreme cyanosis with puffiness of the neck and face and marked dilatation of the superficial veins. Oxygen inhalation had to be administered.

Roentgenogram of the chest showed a large mediastinal tumor measuring 14 cm. in width, which, considering the patient's age, represented an enormous size (Fig. 2). There was marked pressure effect on the large vessels, but no elevation of temperature. The blood count was normal.

Fig. 2. Case II. Aleukemic leukemia. *A*, before treatment; *B*, one week later; *C*, two weeks later. Patient died in four months

The radiosensitivity was compatible with that of lymphosarcoma. Therefore it was decided to administer a second course of radiation therapy over all the palpable lymph node areas, over the entire abdomen and pelvis, and with a lesser dose over the mediastinum. The duration of this course was from 3-8-37 to 4-18-37. The dose amounted to 110 per cent S.U.D. over all areas with 200 kv., 1 mm. Cu, and to 70 per cent S.U.D. with 500 kv., 7 mm. Cu, over the mediastinum.

Since then the patient has continued to enjoy normal health and at the present time there is no evidence of any manifestation of the lymphosarcoma.

9-5-41: Roentgenogram of the chest reveals a normal appearance.

Case II. D. G., male, aged six. Since Christmas, 1933, the patient has developed a gradual

8-14-34 to 8-21-34: Therapeutic test dose was administered over the mediastinum, amounting to 130 per cent S.U.D. with 200 kv., 1 mm. Cu.

8-27-34: Roentgenogram showed marked regression of the tumor.

9-5-34: There was complete disappearance of the tumor.

This "melting away" suggested aleukemic leukemia.

Soon there was generalized adenopathy as well as enlargement of the liver and spleen, with ascites. The leukocyte count rose to 50,000, with 95 per cent immature lymphocytes.

12-14-34: Patient died.

Case III. F., W. male, aged sixty. At the end of August, 1931, the patient rather suddenly developed marked shortness of breath with considerable distention of the epigastric region. One week later, enlargement of the left supra-

clavicular lymph nodes followed.

9-18-31: Examination revealed rather generalized adenopathy. Roentgenogram of the chest showed a tumor of the mediastinum extending toward the right lower lobe, measuring 14 cm. in width. There was beginning collection of pleural fluid (Fig. 3). One lymph node from the left supraclavicular region was removed for biopsy. Microscopic examination showed aleukemic leukemia.

9-18-31 to 9-22-31: Therapeutic test dose given over the mediastinum and right hemithorax. At the same time, the irradiation was extended to the upper abdomen and to both groins. The dose throughout was 90 per cent s.u.d. with 200 kv., 1 mm. Cu.

9-28-31: Roentgenogram of the chest showed rapid regression.

10-23-31: Roentgenogram of the chest revealed a normal appearance. Later there was further extension of the disease and additional series of roentgen therapy were given over the abdomen, pelvis, both axillae and both sides of the neck.

5-7-32: Patient died with terminal picture of acute lymphatic leukemia.

Comment. From the clinical standpoint there are several factors which make the administration of the roentgen therapeutic test dose in this group of special interest:

(1) It is important to differentiate a lymphocytoma from other mediastinal tumors as soon as possible, since the entire subsequent therapeutic procedure depends on an early diagnosis. Inasmuch as distant metastases invariably follow in all cases of this extremely malignant neoplasm, it is our custom to extend the irradiation to all palpable lymph node areas, to the pelvis and entire abdomen from the beginning, regardless of whether metastases have already taken place or not. By pursuing such a radical course, we were able to obtain a 30 per cent five year survival rate in a series of 88 cases of lymphocytoma of all locations. Case 1 illustrates that the same thing applies also to primary lymphocytoma of the mediastinum. The neoplasm in this instance represented, in fact, the largest mediastinal tumor that we have ever encountered.

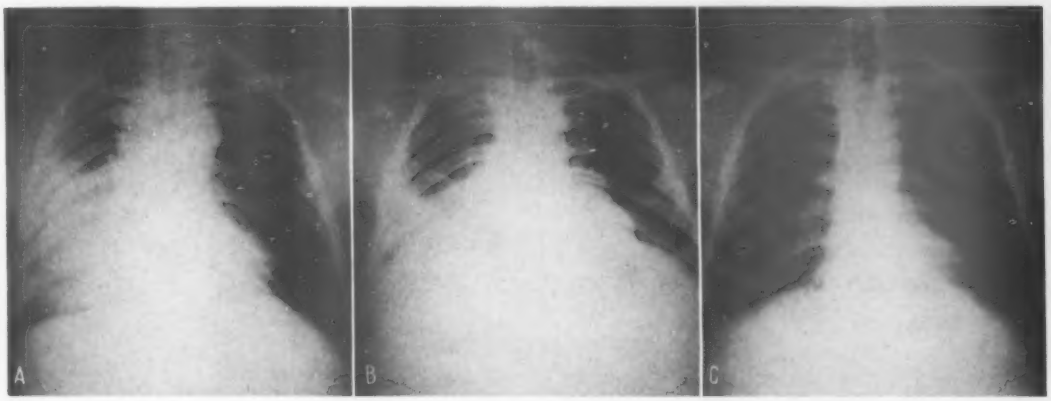

Fig. 3. Case 111. Aleukemic leukemia, transformed later into acute lymphatic leukemia. *A*, before treatment; *B*, one week later; *C*, one month later. Patient died in eight months.

(2) Another situation in which the administration of the roentgen therapeutic test dose leads to worth while information is the aleukemic stage of the acute or subacute lymphatic leukemia, often found in children, as in Case 11. Here, besides the spectacular immediate relief of the distressing symptoms, the blood picture is influenced in such a manner that the presence of a lymphatic leukemia soon becomes evident. There is one case in our series, an adult, in which the condition has been transformed into a chronic leukemia and the patient, after eight years, still enjoys a symptom-free life.

(3) It must be mentioned that in some cases of lymphatic leukemia of very chronic

nature, the regression of the mediastinal manifestations following irradiation occurs at a slower rate than mentioned above. This is due to the more typical and adult morphology of the lymphatic cell proliferations.

Group II. Mediastinal tumors containing predominantly reticulo-endothelial or embryonal spindle-cell elements, such as mediastinal Hodgkin's disease, reticulum-cell sarcoma, endothelioma and embryonal spindle-cell sarcoma.

The rate of regression of these tumors is

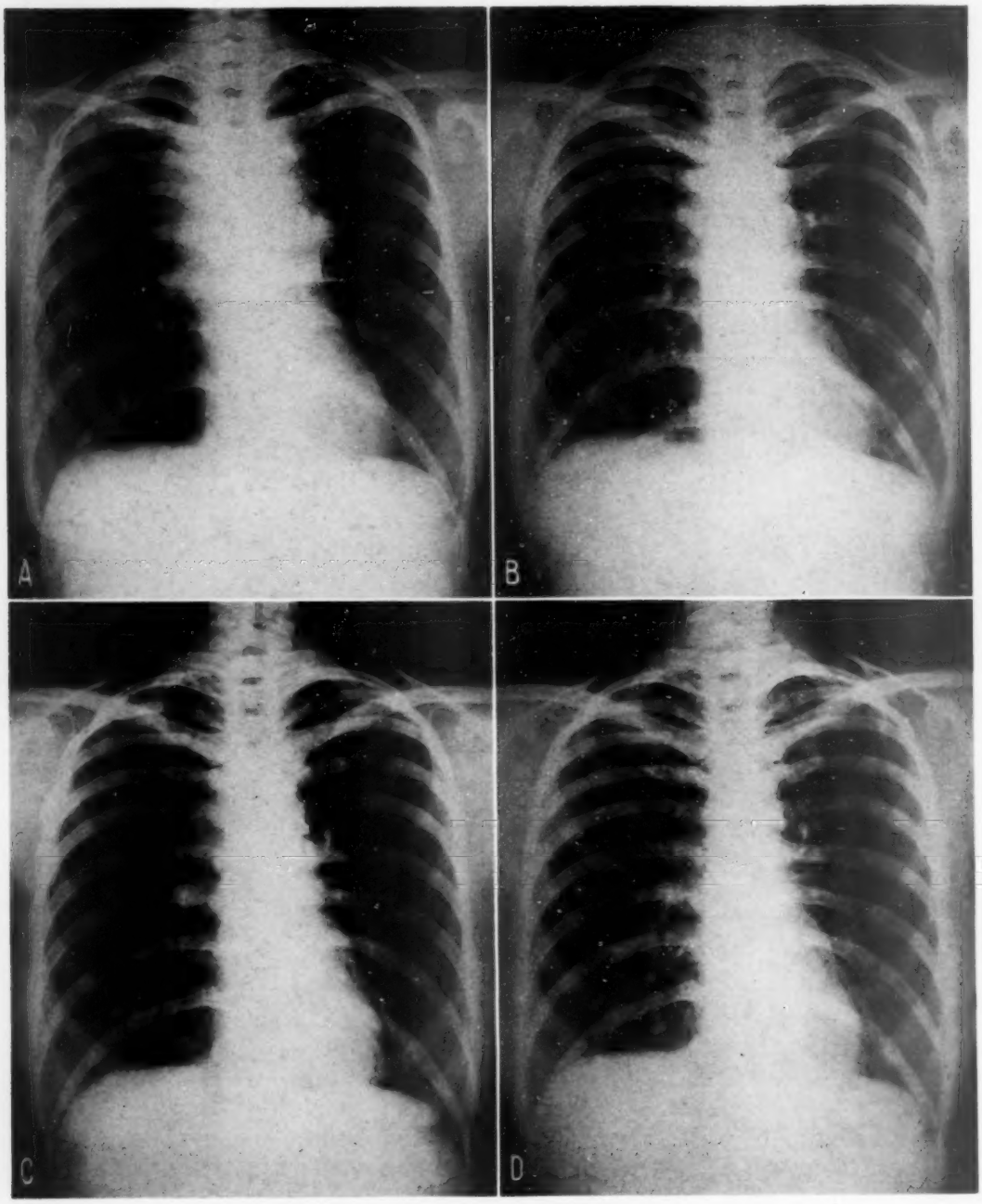

Fig. 4. Case iv. Mediastinal Hodgkin's disease. *A*, before treatment; *B*, six weeks later; *C*, three months later; *D*, four years later. Patient is well.

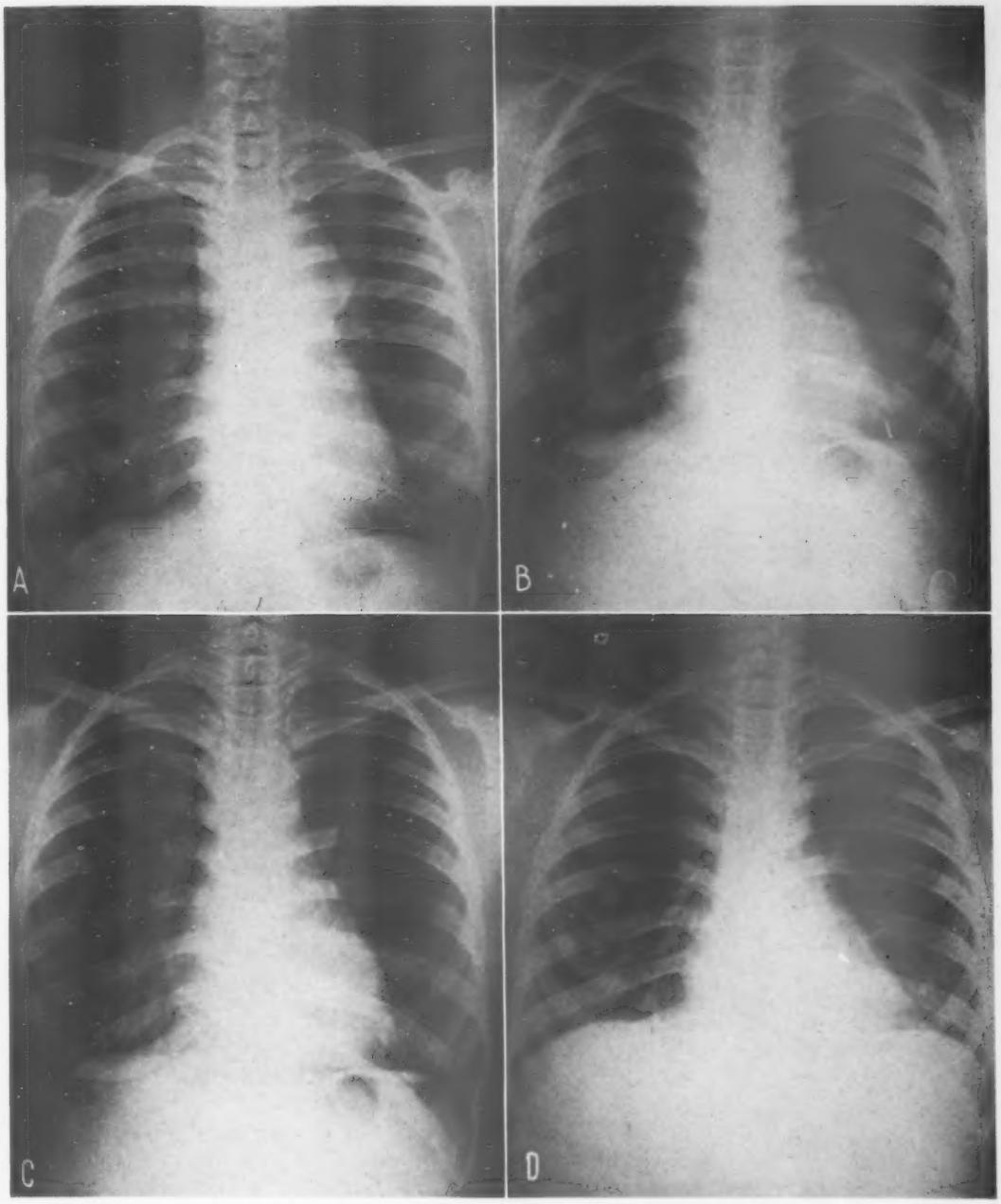

Fig. 5. Case v. Mediastinal Hodgkin's disease. *A*, before treatment; *B*, six weeks later; *C*, three months later; *D*, five years later. Patient is well.

moderate. After two weeks there is a 25 per cent reduction in size, after six weeks a 50 cent or more reduction and after three months nearly always complete disappearance. In this group, often a second series of radiation therapy is given after the six weeks' period, as a rule with considerably lesser dosage. If later a recurrence develops, as sometimes happens especially in the sarcomas, the technique of future irradiation is guided by the individual circumstances.

Case iv. V. R., female, aged thirty-four. Patient had been subject to attacks of hay fever since 1933. In April, 1937, she for the first

time took hay fever injections. Within a few weeks she developed itching of the face, eyes, ears and thighs. Since the end of May, 1937, she noticed enlargement of the lymph nodes of the right supraclavicular region followed by marked cough, with considerable shortness of breath and elevation of temperature to 101.0° F. She lost 15 lb. in weight during a period of six months.

7-7-37: Examination showed marked cyanosis, with a temperature of 100.6° F. and enlargement of the right supraclavicular lymph nodes to 8 cm. in diameter. Roentgenogram of the chest revealed a slightly lobulated mediastinal tumor measuring 12 cm. in diameter (Fig. 4). One lymph node from the supraclavicular region was removed for biopsy. Microscopic examination showed rapidly advancing Hodgkin's disease.

7-8-37 to 7-13-37: Radiation therapy was given over the mediastinum, the dose being 130 per cent S.U.D. with 500 kv., 7 mm. Cu. The irradiation was also extended to the lymph nodes of both sides of the neck and both axillae, with 200 kv., 1 mm. Cu.

9-1-37: Roentgenogram revealed that the mediastinal tumor has decreased to half size.

10-18-37: There was nearly complete disappearance of the tumor.

10-20-37 to 10-26-37: A second course of radiation therapy was given. The dose over the mediastinum was 70 per cent S.U.D., but otherwise the technique of procedure remained the same as for the first series.

Soon after this irradiation, the patient regained her normal health and has continued to remain well.

8-10-41: Roentgenogram of the chest showed a normal appearance.

Case v. Y. D., female, aged thirty-four. Since December, 1935, the patient has felt fatigued, especially toward evening. In August, 1936, she developed enlargement of the right cervical lymph nodes, followed later by severe hacking cough and considerable shortness of breath on exertion. She lost 10 lb. during a period of ten months.

11-21-36: Examination revealed enlargement of the right cervical lymph nodes to 4 cm. in diameter. Roentgenogram of the chest showed enlargement of the mediastinal lymph nodes to 8–10 cm. in diameter (Fig. 5). One lymph node from the cervical region was removed for biopsy. Microscopic examination showed advanced chronic Hodgkin's disease. Within a few minutes following the biopsy, treatment was started.

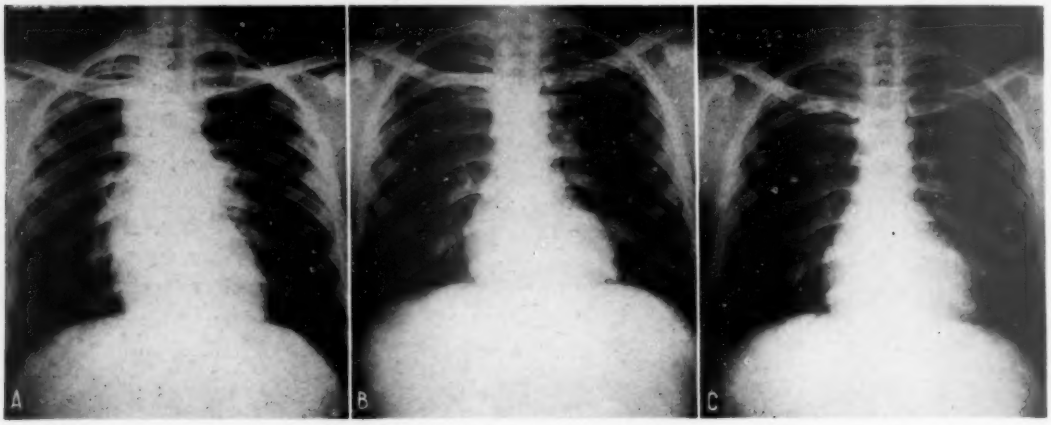

Fig. 6. Case vi. Mediastinal Hodgkin's disease. *A*, before treatment; *B*, three months later; *C*, seven years later. Patient is well.

11-21-36 to 11-25-36: Radiation therapy was administered over the mediastinum, the dose being 130 per cent S.U.D. with 500 kv., 7 mm. Cu. The irradiation then was extended to both sides of the neck and both axillae, with 200 kv., 1.5 mm. Cu.

1-4-37: Roentgenogram of the chest revealed regression to half the original size.

1-4-37 to 1-5-37: A second course of radiation therapy was given over the mediastinum, the dose being 70 per cent S.U.D. with 500 kv., 7 mm. Cu.

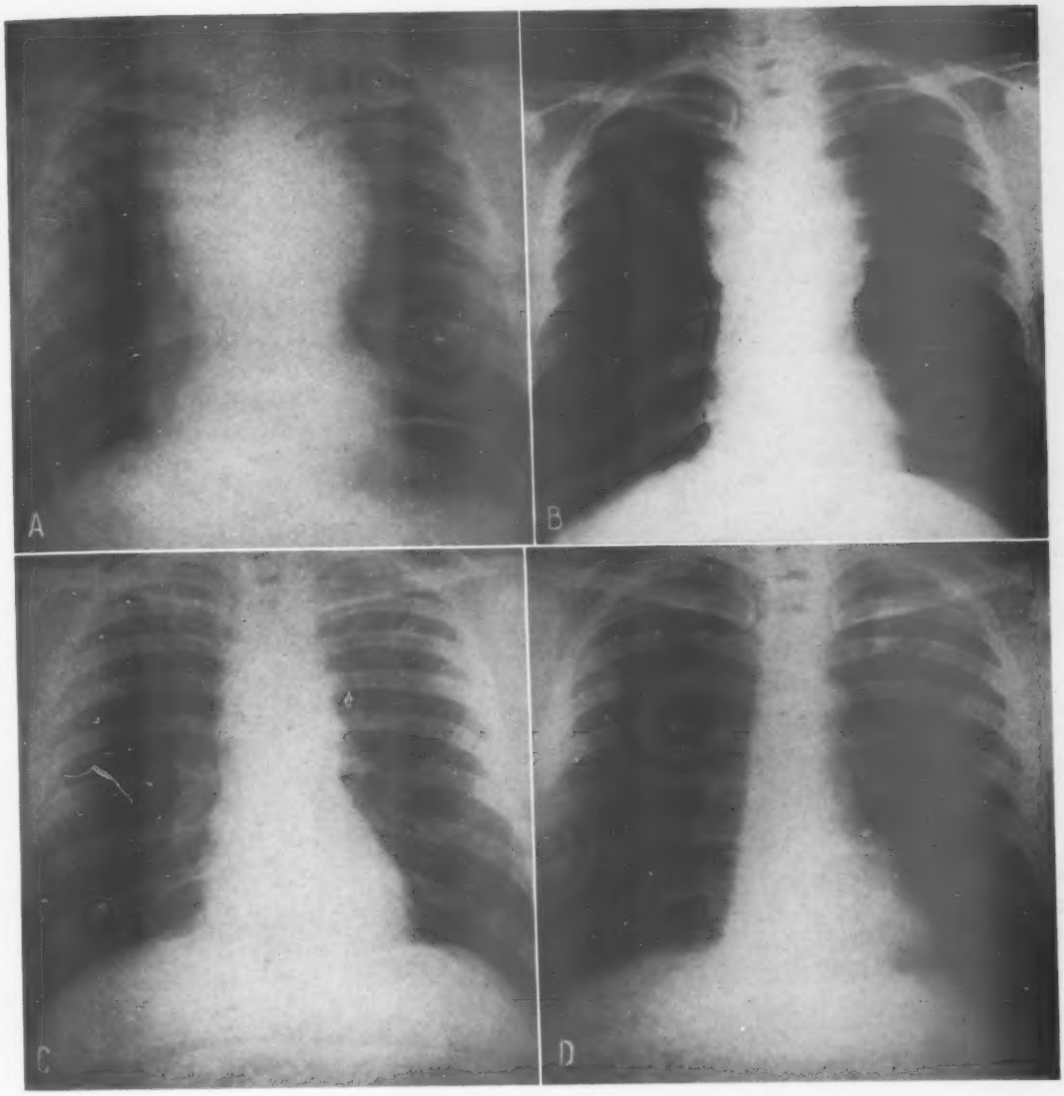

Fig. 7. Case vii. Mediastinal Hodgkin's disease. *A*, before treatment; *B*, three weeks later; *C*, six weeks later; *D*, seventeen years later. Patient is well.

2-15-37: Complete disappearance of the mediastinal tumefaction. Within a few months after the second series of irradiation, the patient regained her normal health and has continued to remain well.

8-22-41: Roentgenogram of the chest showed normal appearance.

Case vi. I. LeG., male, aged twenty-six. Since Christmas, 1933, the patient has developed progressive fatigue, loss of appetite, severe dry hacking cough and an elevation of temperature to as high as 103.0° F. There was a loss of weight of about 15 lb.

5-21-34: Examination revealed enlargement of the lymph nodes of both sides of the neck from 1 to 3 cm. in diameter. A biopsy was suggested, but the patient refused. Roentgenogram of the chest showed an upper mediastinal tumor measuring 9 cm. in width with enlargement of the upper hilar lymph nodes to 3 to 4 cm. in diameter (Fig. 6). The temperature ranged between 99.0 and 103.2° F.

5-21-34 to 5-24-34: Radiation therapy was administered over the mediastinum and both sides of the neck with 200 kv., 1 mm. Cu. The dose was 130 per cent s.u.d. throughout.

8-12-34: Roentgenogram demonstrated a nor-

mal appearance of the chest. The temperature dropped to normal and the patient gained considerable weight. The rate of regression was such as observed in Hodgkin's disease.

In February, 1935, patient developed extension to the inguinal lymph nodes and later to the para-aortic lymph nodes. These were treated in turn with a technique such as used in Hodgkin's disease.

During the subsequent years, there were several recurrent spells and the patient has received radiation therapy with gradually decreasing doses, chiefly over the upper abdomen and spleen, at shorter or longer intervals. The last treatment was administered in September, 1940.

The patient has regained his health and he has been able to work continuously.

8-27-41: Examination revealed the patient to be in excellent condition, there being no manifestations whatsoever of the Hodgkin's disease. Roentgenogram of the chest showed a normal appearance.

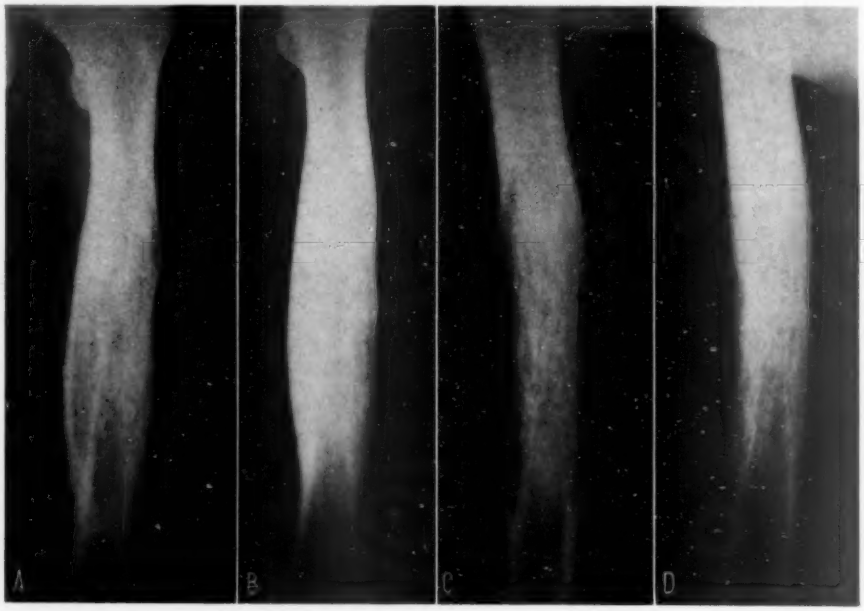

Fig. 8. Case vii. Metastasis of Hodgkin's disease to the shaft of left femur seven years later. *A* and *C*, before treatment, in anteroposterior and lateral views; *B* and *D*, ten years later.

Case vii. W. L., male, aged thirty-eight. In the spring of 1923, the patient developed a dry hacking cough with some hoarseness. In October, he noticed puffiness of the neck with shortness of breath on exertion. By the end of December, 1923, the symptoms had become so severe that the patient was confined to bed.

12-26-23: Examination revealed marked dyspnea with puffiness of both supraclavicular fossae and some swelling of the structures of the neck. There was engorgement of the superficial veins, suggesting pressure effect from a mediastinal tumor.

12-26-23: Roentgenogram of the chest revealed a spherical mediastinal tumor which measured 15 cm. in diameter (Fig. 7).

1-14-24 to 1-19-24: Therapeutic test dose was given over the mediastinum. The condition of the patient improved during the treatment so that the irradiation was then extended to all of the palpable lymph node areas as well as to the pelvis and entire abdomen. The dose amounted to 130 per cent s.u.d. over the mediastinum and 90 per cent s.u.d. over the remaining areas, with 200 kv., 1 mm. Cu.

2-3-24: Roentgenogram showed regression of the mediastinal tumor.

3-9-24: There was further regression, the greatest diameter now being 8 cm.

The rate of regression was in harmony with Hodgkin's disease.

5-12-24 to 5-16-24: A second course of radia-

tion therapy was given, again including the mediastinum, all of the palpable lymph node areas, the pelvis and entire abdomen. The dose amounted to 70 per cent S.U.D. throughout, with 200 kv., 1 mm. Cu.

There was complete recovery and the patient enjoyed good health until May, 1931, when he returned with marked pain in the left mid thigh.

5-7-31: Roentgenograms revealed a destructive area of the mid-portion of the shaft of the left femur, which was interpreted as metastasis from the Hodgkin's disease (Fig. 8).

5-7-31: A third series of radiation therapy was given for this new manifestation of the disease. The dose was 130 per cent S.U.D., with 200 kv., 1 mm. Cu.

6-29-31: The irradiation was repeated, with the same technique.

Within a few months the patient was able to resume his occupation and has remained normal.

5-7-41: Roentgenograms of the chest and left femur revealed the condition satisfactory.

CASE VIII. F. McI., male, aged thirty-nine. For several years, patient received antiluetic therapy at irregular intervals. Since November, 1939, he has noted a gradually enlarging tumor of the left anterior chest wall, associated with dry, hacking cough, and followed later by marked shortness of breath. There was no elevation of temperature.

2-15-40: Examination revealed a left parasternal tumor, 10 cm. in diameter at the base and rising 4 cm. above the surface of the chest wall, without pulsation. The Kahn test was 4 plus. Patient had marked cyanosis with engorgement of the superficial veins, suggesting secondary pressure effect in the upper mediastinum.

2-15-40: Roentgenograms of the chest in various views and kymographic study showed a large tumor in the upper mediastinum, measuring 16 cm. in width. There was perforation of the sternum and left anterior ribs. It appeared that the tumors of the anterior chest wall and the upper mediastinum were parts of the same neoplasm. A clinical diagnosis of aneurysm was made (Fig. 9).

2-15-40 to 3-2-40: Therapeutic test dose was given over the tumor, amounting to 130 per cent S.U.D., with 500 kv., 7 mm. Cu. Because of the marked cyanosis, the fractionated method was used.

5-2-40: There was marked regression of the tumor.

5-6-40 to 5-11-40: A second course of radiation therapy was given over the mediastinum, the dose being 70 per cent S.U.D. with 500 kv., 7 mm. Cu.

6-22-40: The tumor practically disappeared. The rate of regression was compatible with Hodgkin's disease.

8-22-41: Roentgenogram revealed a normal chest.

Comment. This group is practically dominated by mediastinal Hodgkin's disease. Reticulum-cell sarcoma and endothelioma occur very rarely as primary tumors of the mediastinum and in the embryonal sarcomas diagnosis is usually established by other means.

In connection with Hodgkin's disease, two factors are of special interest: (1) As in lymphocytoma, the early diagnosis of a mediastinal Hodgkin's disease is important for the outlining of further therapy, although here the irradiation is confined to the actual manifestations of the disease. The surprising fact in our series was that 33 per cent of the cases treated have survived the five year period and that those who died have only in exceptional instances shown a mediastinal recurrence. The longest survival was seventeen years (Case VII), the patient having received no treatment for the past ten years and is enjoying normal health at the present time. (2) The second factor is that mediastinal Hodgkin's disease not infrequently invades the anterior thoracic wall, producing external tumefaction, which, especially in the presence of a positive serologic test, is exceedingly difficult to differentiate from aneurysm. This has occurred four times in our series and Case VIII is a good example of it.

Group III. Other malignant tumors of the mediastinum, such as fibrosarcoma, melanosarcoma, carcinoma of the thyroid and thymic glands, teratoma, etc.

The rate of regression of these tumors is slow. After two weeks, there is hardly any reduction in size, after six weeks there is a 20–50 per cent reduction and after three months in the majority of the cases there

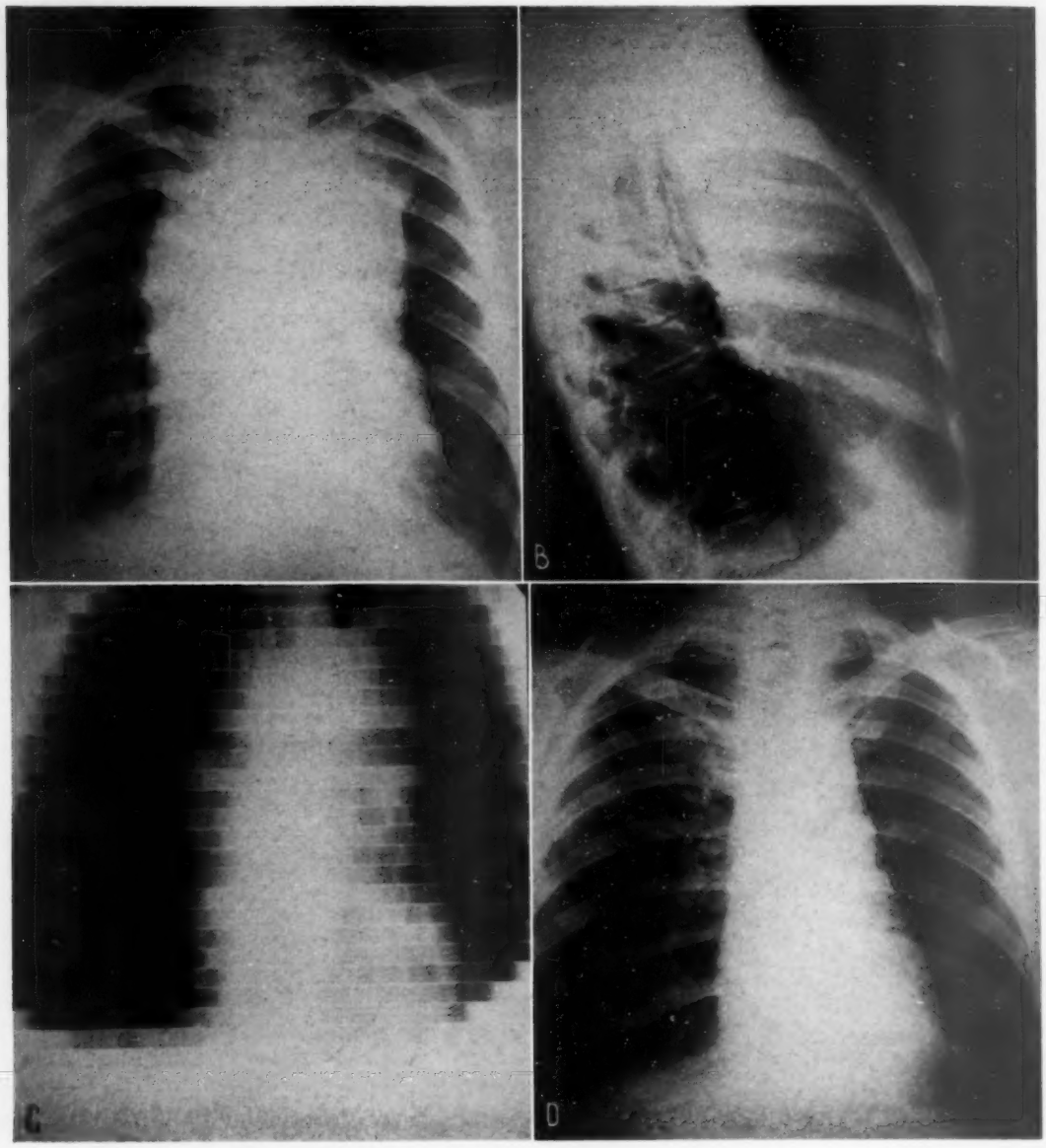

Fig. 9. Case viii. Mediastinal Hodgkin's disease, clinically diagnosed as aneurysm. *A*, before treatment; *B*, same, lateral view, showing erosion of ribs and sternum; *C*, same, kymogram; *D*, one and one-half years later. Patient is well.

is again progression. In some instances, by administering further intensive irradiation, a notable prolongation of life or even five year survival is obtained.

Case ix. H. R., female, aged thirty-nine. Since the summer of 1930, patient has developed a dry hacking cough soon associated with progressive shortness of breath. During January, 1941, a marked puffiness of the neck and face appeared and for one week prior to treatment, there was extreme cyanosis.

2-12-31: Examination revealed a large mediastinal tumor (Fig. 10) measuring 16 cm. in width and extending mostly into the right hemithorax. There was a marked pressure effect on the large vessels with engorgement of the superficial veins. Oxygen inhalation had to be administered.

The differential diagnosis was between lym-

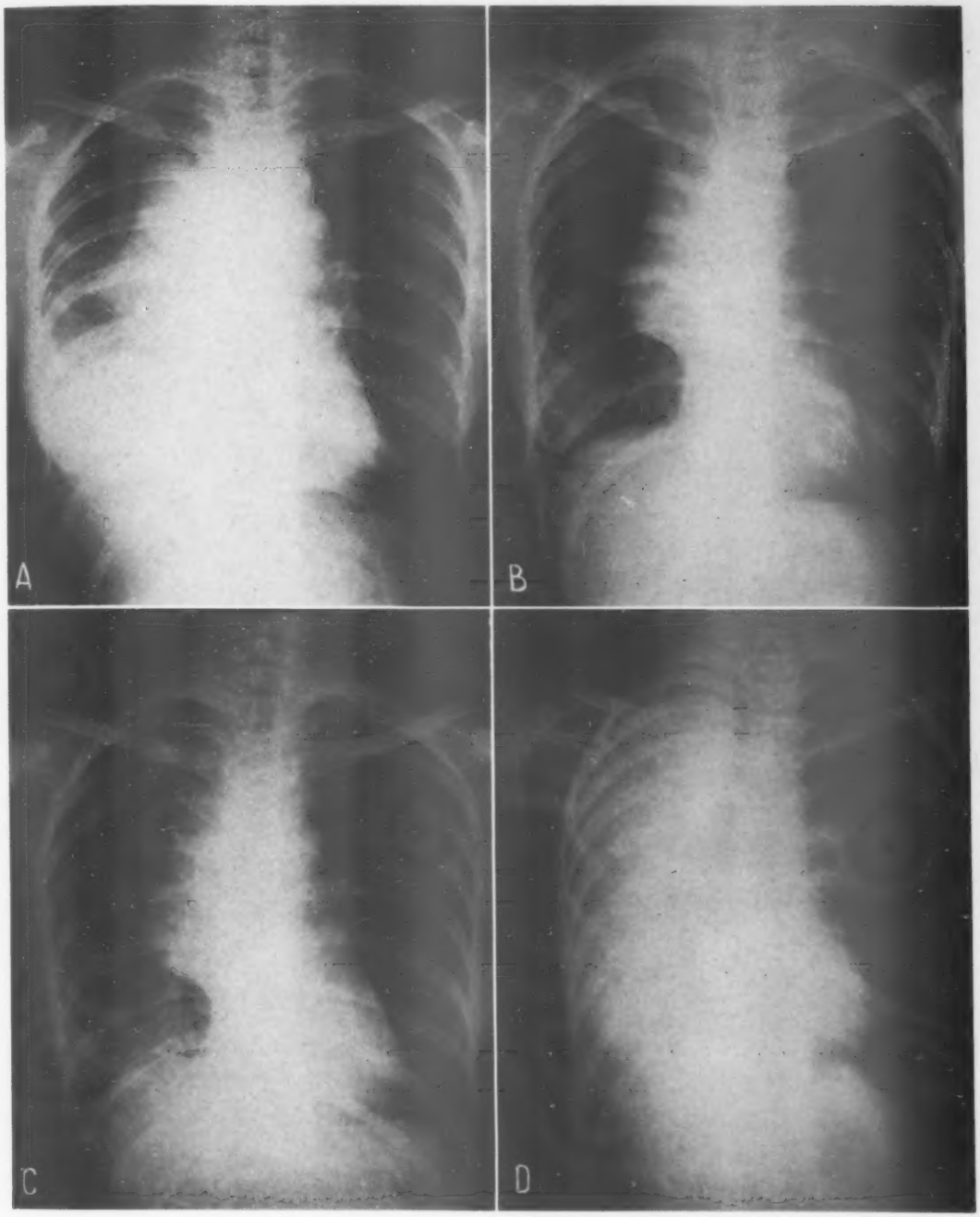

Fig. 10. Case IX. Fibrosarcoma. *A*, before treatment; *B*, one month later; *C*, two months later; *D*, five years later. A massive fibrosis of the right hemithorax was produced. Patient died after six years from distant metastases.

phosarcoma, fibrosarcoma and mediastinal Hodgkin's disease.

2-12-31 to 2-19-31: Therapeutic test dose was administered over the mediastinum and the irradiation was also extended to the lymph nodes of both sides of the neck, the axillae and the upper abdomen. The dose amounted to 130 per cent S.U.D. throughout, with 200 kv., 1 mm. Cu.

3-14-31: Roentgenogram of the chest revealed

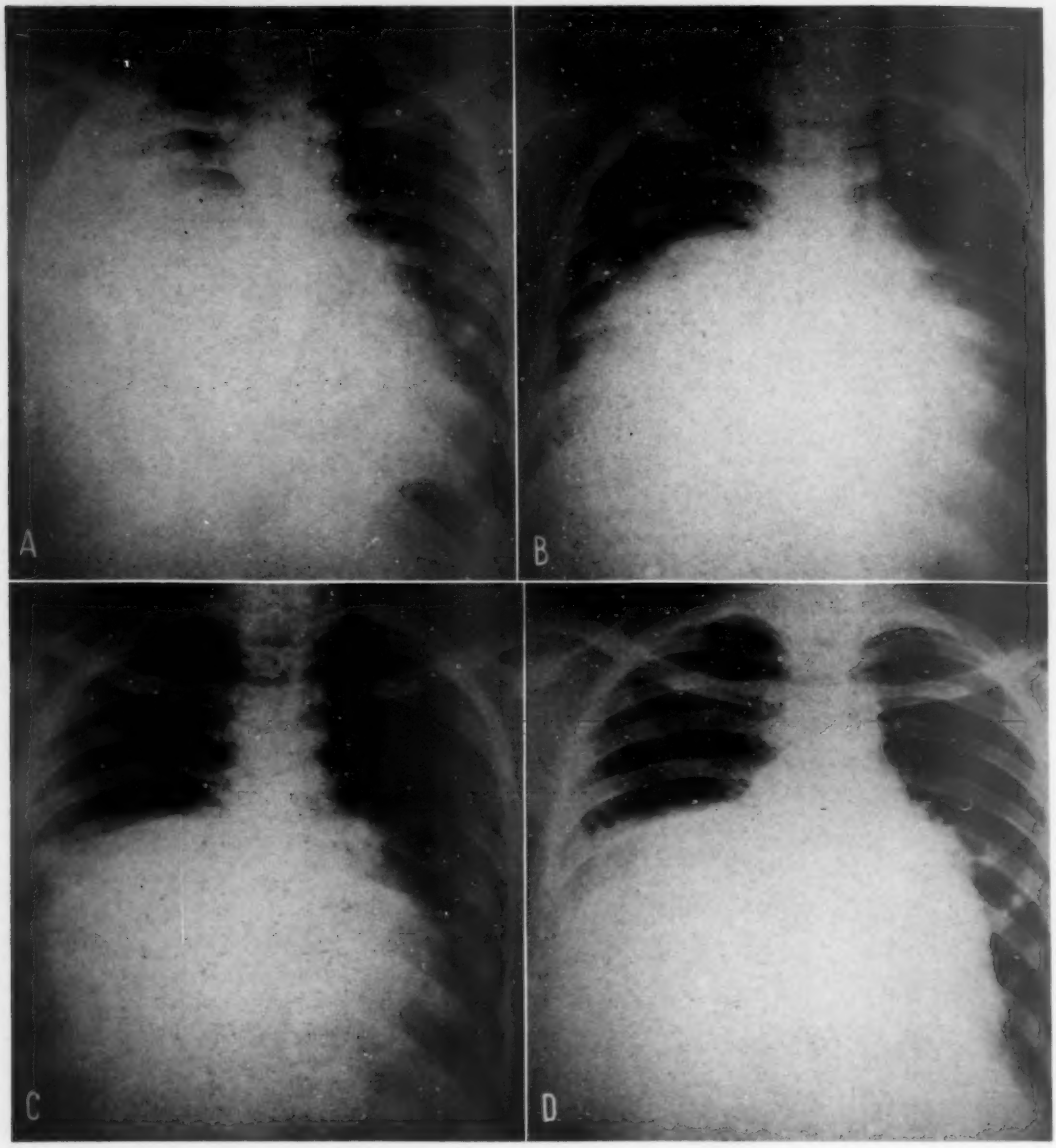

Fig. 11. Case x. Fibrosarcoma with massive pleural effusion. *A*, original status; *B*, after aspiration of fluid and injection of air; *C*, six weeks after roentgen therapeutic test dose; *D*, another six weeks later. Patient died in eight months.

regression of the mediastinal tumor to half the original size.

4-4-31: Roentgenogram of the chest showed again progression of the tumor. This behavior was compatible with fibrosarcoma.

4-21-31 to 4-22-31: A second course of radiation therapy was given over the mediastinum and right hemithorax, this time with the purpose of producing fibrosis. The dose was 110 per cent S.U.D.

Subsequent roentgenograms revealed a gradually developing fibrosis of the right thorax, as expected.

1-25-36: There was massive fibrosis, with the tumor apparently arrested.

During the late spring, 1936, distant metastases developed.

12-16-36: Patient died. The final diagnosis was that of fibrosarcoma.

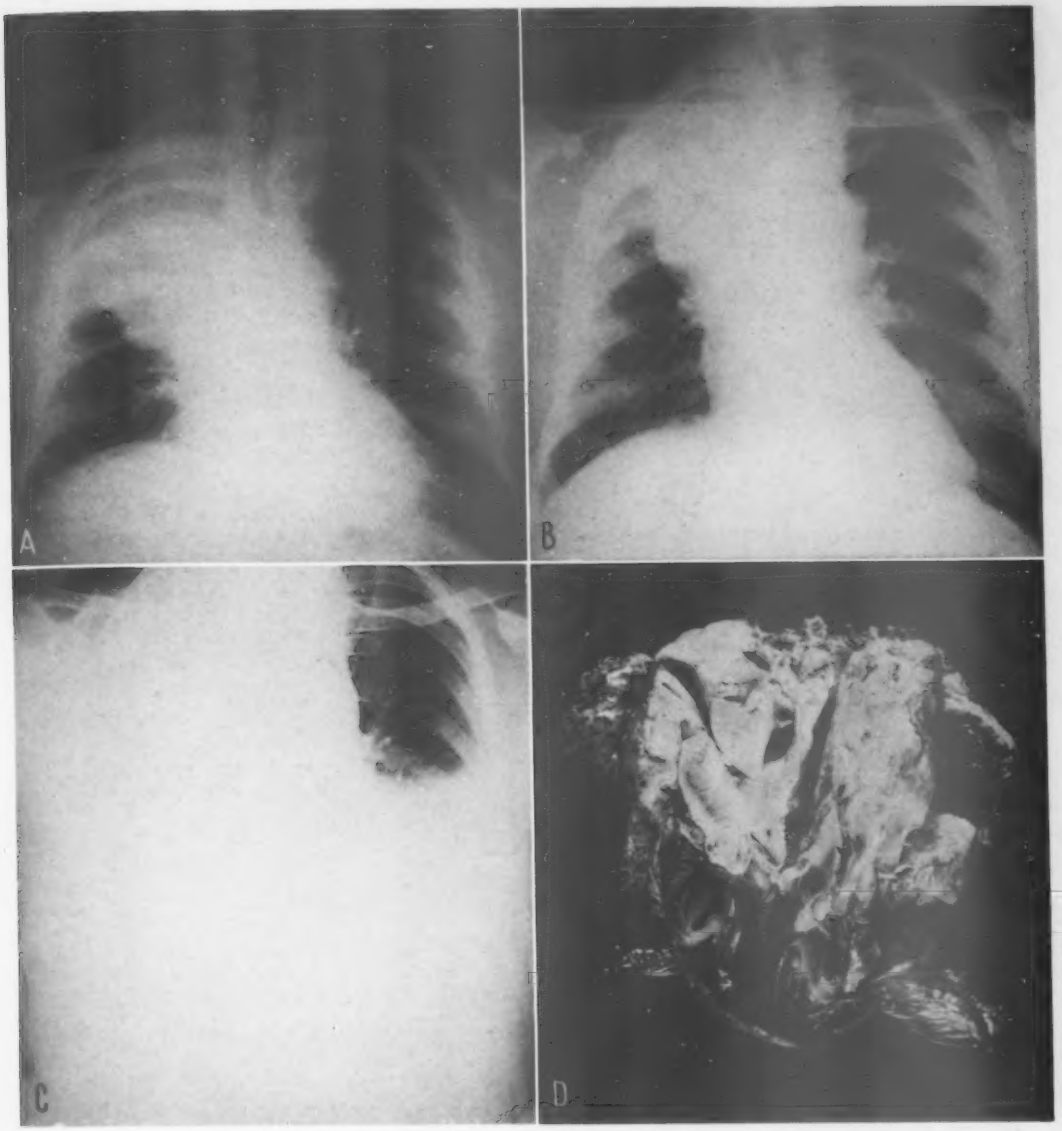

Fig. 12. Case xi. Carcinoma of thymic gland, with atelectasis of right upper lobe. *A*, before treatment; *B*, six weeks later; *C*, five months later; *D*, specimen. Patient died in six months.

Case x. R. R., male, aged twenty. Since January, 1930, patient has been complaining of night sweats, impaired appetite, loss of 25 lb. in weight, shortness of breath and weakness on exertion. During August and September, 1930, he had three pleural aspirations of about 1,000 cc. each. A clinical diagnosis of probable tuberculosis was made.

10-25-30: Roentgenograms following the aspiration of fluid and injection of air revealed a huge tumor 20 by 25 cm. in diameter behind the heart and extending into the proximal two-thirds of the right lung field area (Fig. 11).

10-27-30 to 11-6-30: Therapeutic test dose was given over the lower two-thirds of the right chest and entire mediastinum amounting to 130 per cent s.u.d. with 200 kv., 1 mm. Cu. Because of the marked shortness of breath, oxygen had to be administered during the irradiation and the fractionated method employed.

12-15-30: Roentgenogram revealed definite regression in the size of the tumor. The radiosensitivity was compatible with fibrosarcoma.

12-15-30 to 12-19-30: A second series and

from 2-9-31 to 2-14-31 a third series of radiation therapy was administered.

After temporary improvement the condition grew worse and on June 5, 1931, the patient died. Postmortem examination revealed fibrosarcoma.

Case xi. G. T., male, aged fifty-six. In January, 1933, the patient rather suddenly developed a puffiness of the neck followed by a dry hacking cough and within three weeks by rather severe hemoptysis. The end of February, 1933, the hemoptysis recurred.

3-7-33: Examination revealed marked shortness of breath with blood-streaked sputum. Roentgenogram showed a tumor in the upper mediastinum about 12 cm. in diameter which has compressed the bronchus of the right upper lobe and has led to atelectasis of this latter (Fig. 12). The Kahn test was 3 plus. Differential diagnosis included aneurysm, bronchiogenic carcinoma, fibrosarcoma and carcinoma of the thymus gland.

3-7-33 to 3-10-33: Therapeutic test dose was given over the right upper chest and mediastinum amounting to 130 per cent s.u.d., with 200 kv., 1 mm. Cu.

4-28-33: Roentgenogram showed definite reduction in the size of the tumor indicative of a malignant process, but permitting no further differentiation.

5-31-33 to 6-3-33: A second course of radiation therapy was administered with the same technique.

8-10-33: Roentgenogram demonstrated massive pleural effusion of the right chest and also a slight amount of effusion in the left lower chest. Because of this, it was thought that the malignant neoplasm was most probably in the upper mediastinum. The development of pleural effusion so soon after the irradiation suggested poor radiosensitivity with rather high degree of differentiation of the tumor cells.

9-7-33: Patient died. Specimen: Large neoplasm of the upper mediastinum. Microscopic: Carcinoma of the thymic gland.

Case xii. E.D., female, aged fifty-eight. In the summer of 1930, the patient developed recurrent pain in the right shoulder. In August and September, 1930, she had repeated small hemoptyses. There was also a dry hacking cough and some expectoration. A larger hemoptysis occurred in October, 1930.

Fig. 13. Case xii. Bronchiogenic carcinoma with atelectasis of right upper lobe. *A*, before treatment; *B*, one month later; *C*, seven months later. Patient died in eight months.

10-10-30: Examination revealed a dullness of the right upper lung with some cyanosis and a blood-streaked sputum.

Roentgenogram showed atelectasis of the right upper lobe secondary to an obstructive lesion in the right upper lobe bronchus or to aneurysm (Fig. 13). The Kahn test was 4 plus. A bronchoscopic examination failed to reveal the site of the tumor.

10-28-30 to 10-30-30: Therapeutic test dose was administered over the right upper chest amounting to 130 per cent s.u.d., with 200 kv., 1 mm. Cu.

11-20-30: Roentgenogram revealed a clearing up of the atelectasis with definite visualiza-

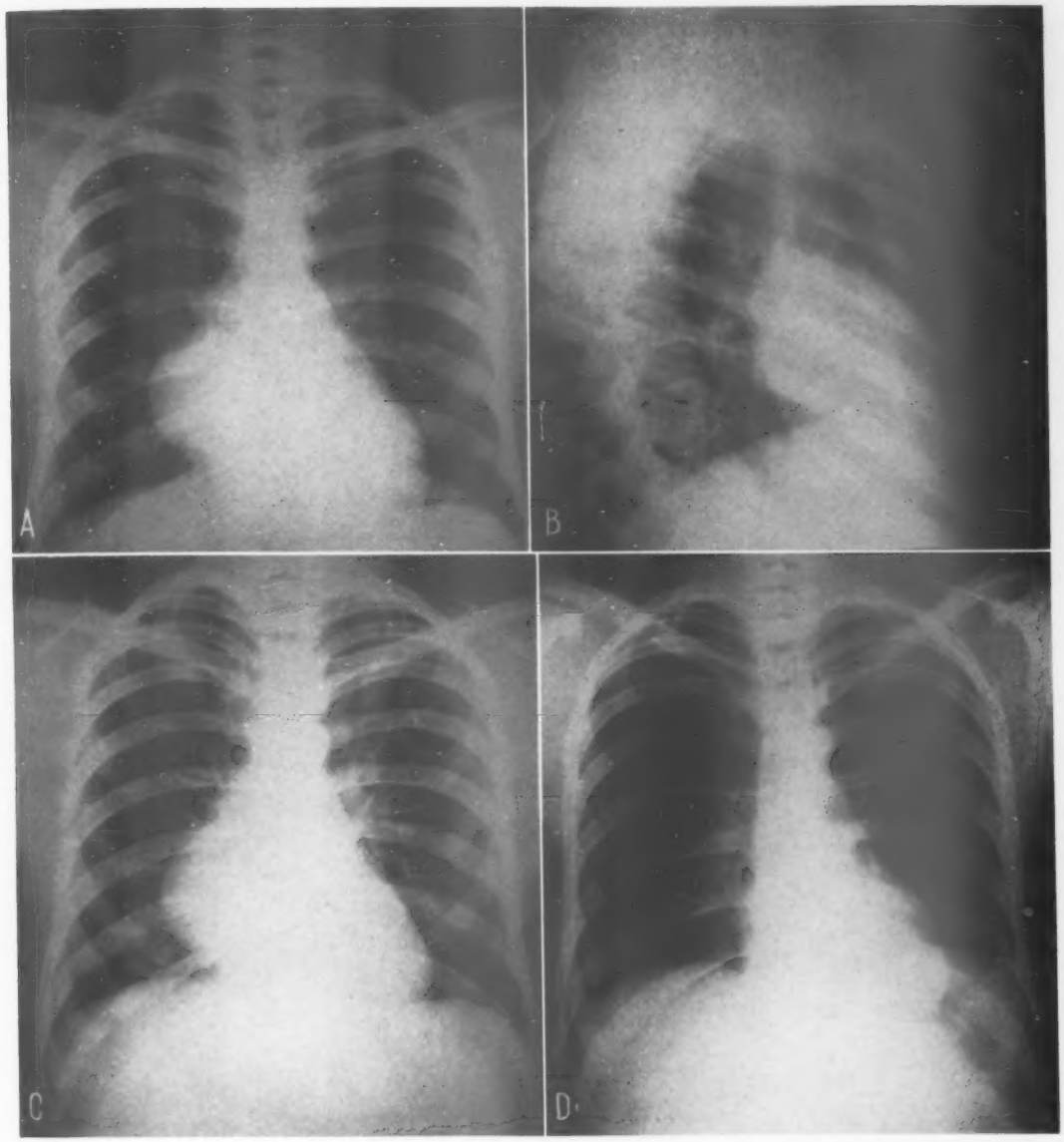

Fig. 14. Case xiii. Dermoid behind the right border of the heart. *A*, before treatment; *B*, same, lateral view; *C*, three months later and just preceding extirpation; *D*, six years later. Patient is well.

tion of the tumor shadow which now was 4 cm. in diameter. This was diagnosed as bronchiogenic carcinoma.

1-7-31 to 1-10-31: A second course of radiation therapy was administered with the same technique.

5-29-31: There was massive pleural effusion in the right chest. Soon after this, cardiac decompensation developed and on June 14, 1931, the patient died. Postmortem examination confirmed the diagnosis of bronchiogenic carcinoma.

Comment. This group, in reality, may be termed a group by exclusion. All tumors which cannot be fitted in the other groups are placed herein, with the notation that they represent malignant neoplasms of low radiosensitivity. But beyond that the application of the roentgen therapeutic test dose permits no further differentiation.

Group IV. Benign tumors of the mediastinum such as neuroganglioma, dermoid cyst, chondroma, fibroma, lipoma, etc.,

and pseudotumors, such as aneurysm, encysted fluid, encapsulated abscess, echinococcus cyst, etc.

These tumors are uninfluenced by the administration of the roentgen therapeutic test dose, so that periodical checkup examinations reveal no change or very slow increase in size, compatible with the nature of the lesion. A possible exception is the large fibroma which seems to behave in a manner similar to that observed in large uterine fibroids (Case xvi).

Case xiii. L. H. C., male, aged twenty-four. In the summer of 1933, the patient had pneumonia from which he recovered following medical treatment. However, he continued to have intermittent pain in the right lower chest. In September, 1935, the pain became more severe and a shortness of breath developed on the slightest exertion. Soon after that the patient started to become fatigued and by December, 1935, he had to rest a great deal of the time, although he was not confined to bed.

12-14-35: Examination revealed some dyspnea and physical signs pointing toward a proc-

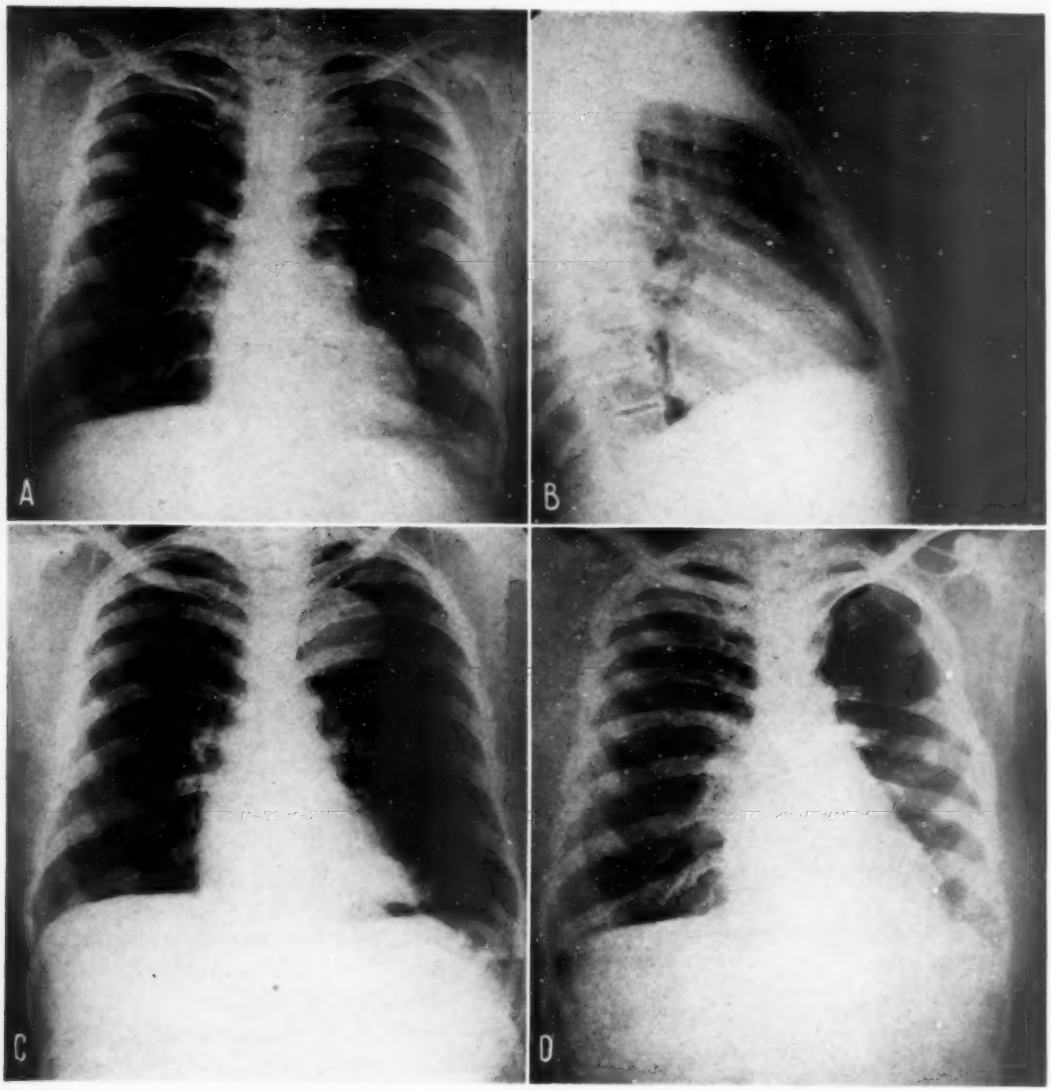

Fig. 15. Case xiv. Leiomyofibroma. *A*, before treatment; *B*, same, lateral view; *C*, one year later and just preceding mediastinotomy; *D*, four years later. Patient is well.

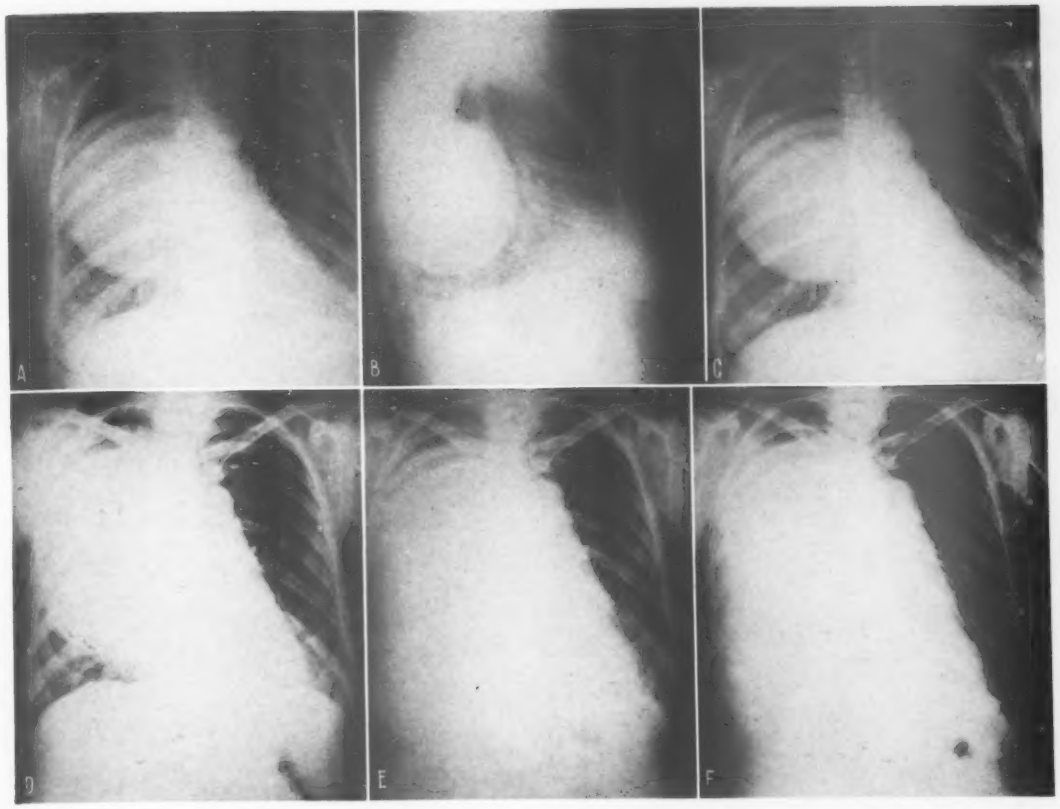

Fig. 16. Case xv. Dermoid. *A*, before treatment; *B*, same, lateral view; *C*, one year later; *D*, ten years later; *E*, ten years and one month later; *F*, thirteen years later. Patient is living.

ess near the root of the right lung.

Roentgenogram showed a lobulated tumor behind the right border of the heart which was thought to measure about 10 by 12 cm. with the longer axis vertically (Fig. 14).

12-18-35 to 12-21-35: Therapeutic test dose was given over the tumor behind the right border of the heart, amounting to 130 per cent s.u.d., with 200 kv., 1 mm. Cu.

Subsequent checkup roentgenograms revealed no change in size. The radiosensitivity was compatible with a benign tumor, therefore its surgical removal was recommended.

3-24-36: The tumor was extirpated through an intercostal incision by Drs. O'Brien and Tuttle. Pathologic report: Large encapsulated tumor measuring 10 by 12 cm., slightly lobulated, of homogeneous consistency. Microscopic: Dermoid with extraordinary development of thin-walled blood vessels.

9-1-41: Roentgenogram showed the chest to be of normal appearance. The patient is enjoying normal health.

Case xiv. L. T., female, aged forty. Since the fall of 1934, the patient has had recurrent attacks of dyspnea, cough and palpitation on exertion. She has also had intermittent swelling of the ankles. In the summer of 1937, she developed sharp pain radiating into the left shoulder.

11-30-37: Physical examination revealed nothing of diagnostic significance. The blood count and blood chemistry have shown normal figures. Kahn negative. Electrocardiogram showed a normal curve. Basal metabolic rate +4 per cent.

Roentgenogram of the chest showed a spherical tumor in the superior mediastinal region just to the left of the midline. The tumor measured 6 cm. in diameter (Fig. 15).

12-1-37 to 12-4-37: Therapeutic test dose was given over the upper mediastinum amounting to 130 per cent s.u.d., with 500 kv., 7 mm. Cu.

Subsequent checkup roentgenograms demonstrated no change in the size of the tumor which

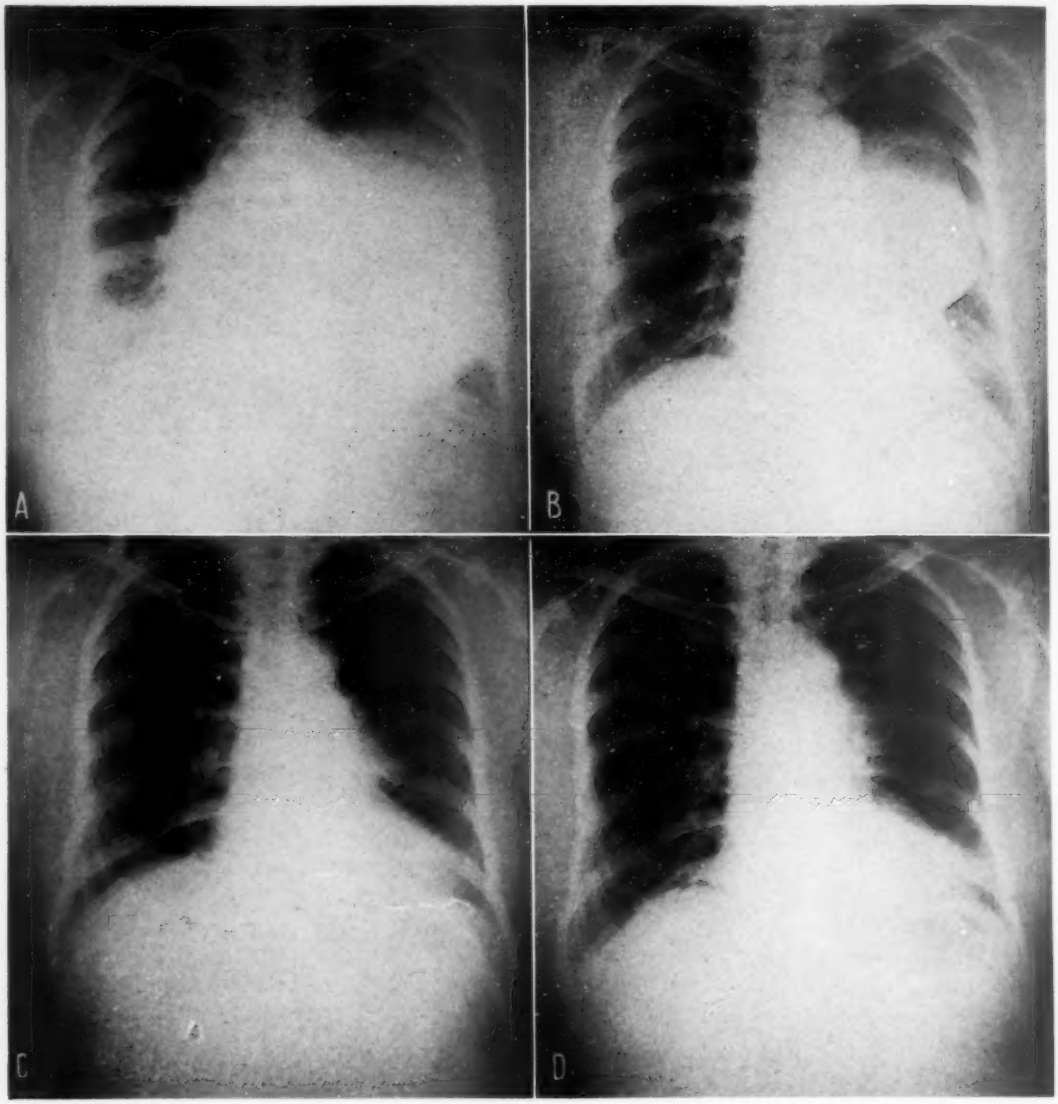

Fig. 17. Case xvi. Questionable fibroma. *A*, before treatment; *B*, six months later; *C*, one year later; *D*, five years later. The patient is in good health after nine years.

on November 30, 1938, was still 6 cm. in diameter.

The radiosensitivity was compatible with a benign tumor and therefore its surgical removal was recommended.

12-1-38: Mediastinotomy performed for extirpation of tumor by Drs. O'Brien and Tuttle.

Pathologic report: Rounded tumor mass 6 cm. in diameter, well encapsulated, of somewhat gelatinous appearance. Microscopic: Leiomyofibroma.

The patient made an uneventful postoperative recovery.

8-20-41: Roentgenogram showed normal appearance of the chest. The patient is enjoying good health.

Case xv. E. P., female, aged forty-nine. Since 1924 the patient observed pain in the right chest with slowly developing shortness of breath. By the end of 1927, this latter was so pronounced that she had to slow down a great deal.

2-16-28: Examination revealed a fairly good general condition with practically no dyspnea. The shortness of breath was noted only following exertion.

Roentgenogram of the chest demonstrated a

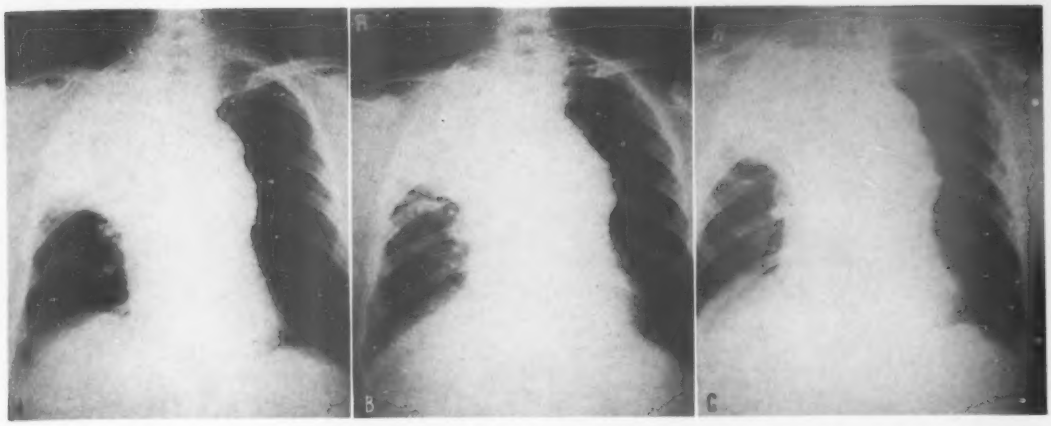

Fig. 18. Case xvii. Aneurysm. *A*, before treatment; *B*, three months later; *C*, one year later. Patient died after one year and two months.

spherical tumor 15 cm. in diameter (Fig. 16). The appearance was that of a cyst; nevertheless, it was decided to test its radiosensitivity.

2-16-28 to 2-21-28: A full course of radiation therapy was administered over the right hemithorax, the dose amounting to 130 per cent s.u.d., with 200 kv., 1 mm. Cu.

The patient continued to enjoy good health and repeated roentgenograms revealed no change in the size of the tumor.

5-7-38: Patient returned complaining of very marked pain in the right lower chest and quite pronounced shortness of breath. A roentgenogram at this time showed the tumor to be nearly 20 cm. in diameter.

6-15-38: The shortness of breath was still more pronounced. Another roentgenogram revealed marked pleural effusion of the right hemithorax now obscuring the tumor shadow. This new development was interesting since only five weeks previously no pleural effusion was present. Subsequently several series of

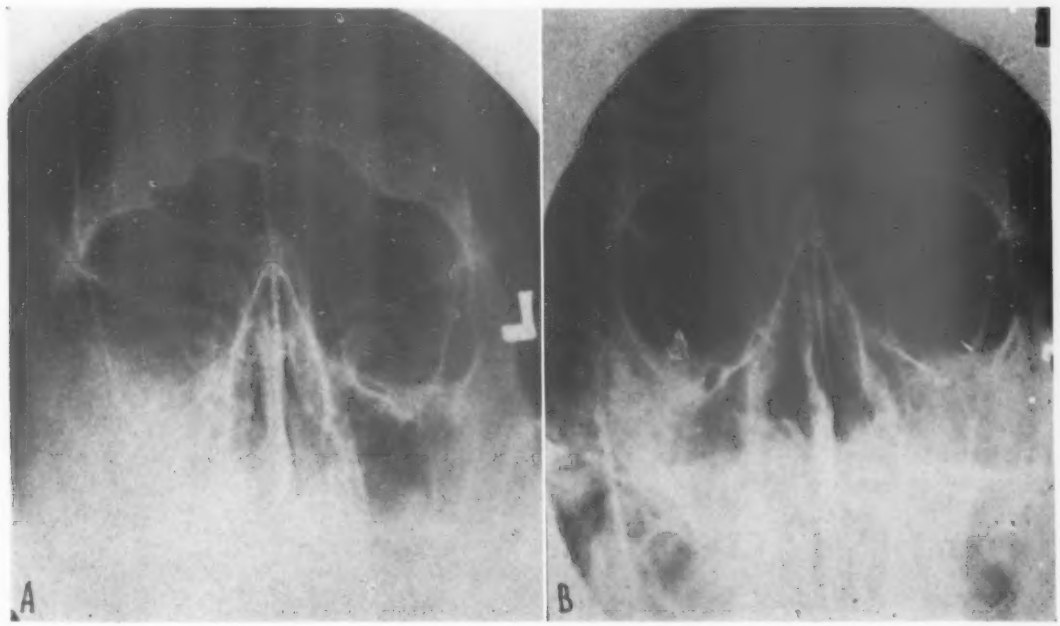

Fig. 19. Case xviii. Osteogenic sarcoma of right maxilla successfully treated in 1935 by four series of radiation therapy. *A*, before treatment; *B*, four years later.

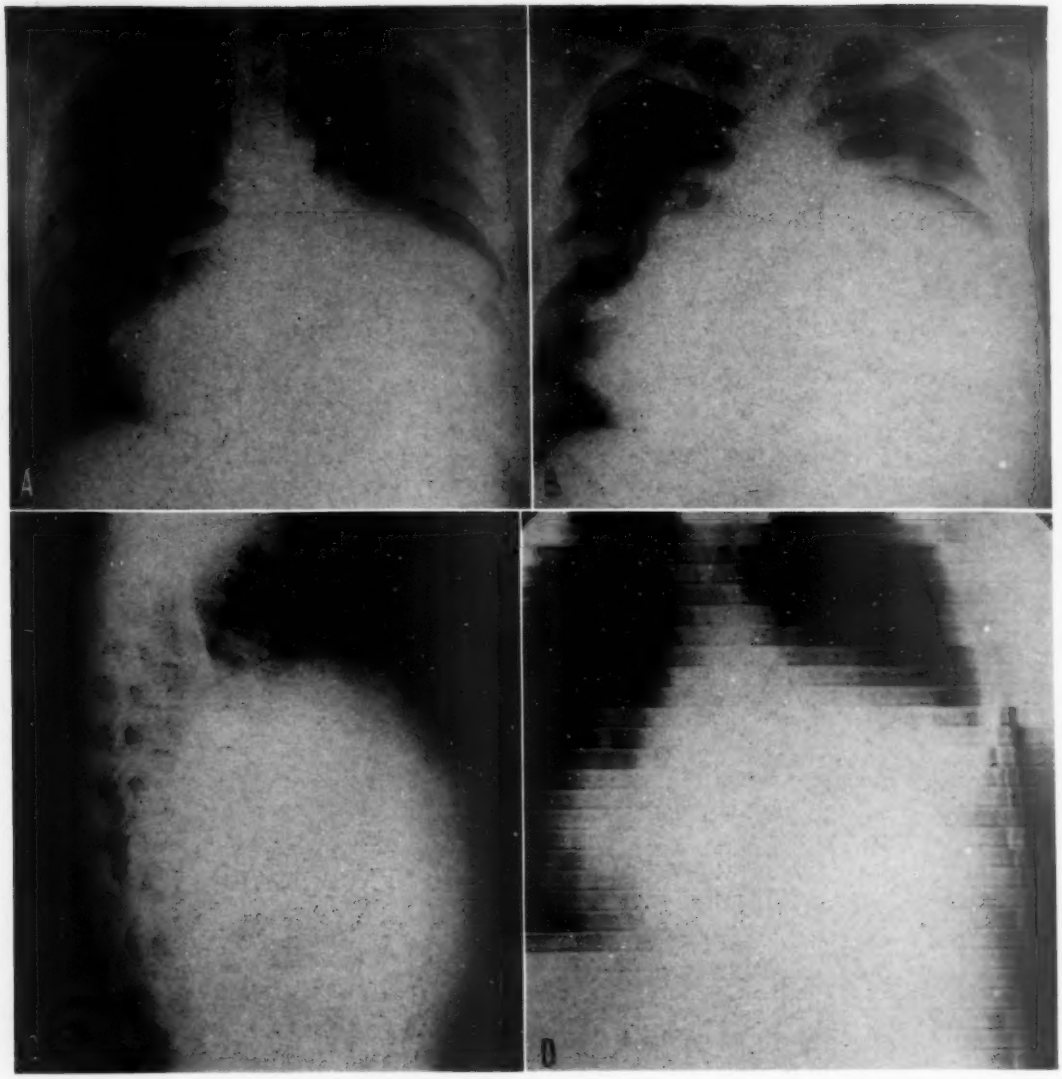

Fig. 20. Same case as Figure 19, showing condition of the heart nearly one year later. The possibility of metastatic sarcoma was considered and roentgen therapeutic test dose given. *A*, before treatment; *B*, three years later; *C*, same, lateral view; *D*, same, kymogram.

radiation therapy were given over the right hemithorax with the aim of producing a fibrosis which would dry up the fluid.

8-4-41: Roentgenogram showed good fibrosis of the right hemithorax. The tumor shadow was obscured by the massive opacity. No aspiration of the chest was ever done. The patient continues in fair health.

Case xvi. E. J., female, aged forty-nine. During the summer of 1931, the patient experienced some shortness of breath with a slight hacking cough after exertion. These symptoms have slowly but gradually increased in intensity so that by September, 1932, the patient was quite ill, being confined to bed a great deal. In addition, she has developed severe pain in the left lower chest.

9-19-32: Roentgen examination revealed a tumor of the left lung measuring 18 cm. in diameter, suggestive of a cyst (Fig. 17).

9-19-32 to 9-22-32: Therapeutic test dose was given, amounting to 130 per cent s.u.d., with 200 kv., 1 mm. Cu.

Subsequent roentgenograms revealed a slow but gradual reduction in the size of the tumor

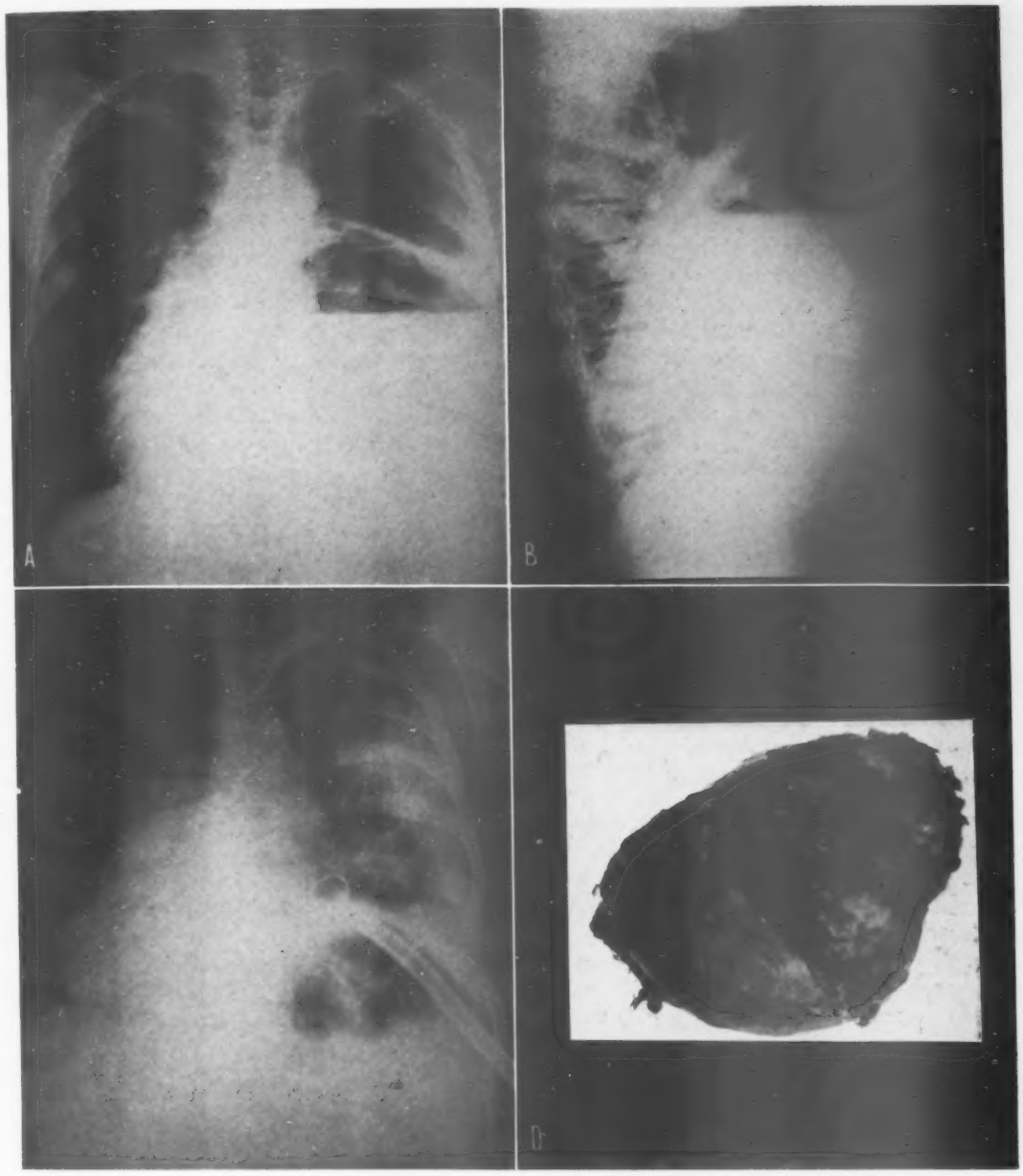

Fig. 21. Same case as Figure 20, another three months later. At this time a dermoid was suspected and aspiration done. *A*, condition after aspiration; *B*, same, lateral view. About two weeks later a pedunculated dermoid of the mediastinum just behind the heart was removed surgically. *C*, one week after surgery; *D*, specimen. The heart was normal. The patient died of pneumonia two weeks after operation.

so that on March 25, 1933, it measured 12 cm. in diameter, on September 16, 1933, 7 cm. in diameter and by 1937 it had completely disappeared.

The radiosensitivity of this tumor is not entirely clear. However, from comparison with the radiation response of large uterine fibroids which often take two to three years to completely disappear, it was assumed that its nature was most probably that of a fibroma.

The patient enjoys good health at the present time, nine years later.

Case xvii. W. J. M., male, aged fifty-eight.

On October 15, 1924, the patient suddenly developed a hemoptysis and coughed up about half a pint of blood. This was followed by a severe dry hacking cough and night sweats.

11-3-24: Physical examination revealed a dullness of the upper half of the right lung. The patient was an old luetic and he had a 4 plus Wassermann.

11-10-24: Roentgenogram showed a slight lobulated spherical tumor of the mediastinum measuring 14 cm. in diameter. The tumor produced a pressure effect on the bronchus of the right upper lobe with secondary atelectasis (Fig. 18). The differential diagnosis included aneurysm, bronchiogenic carcinoma, fibrosarcoma and carcinoma of the thymic gland, the appearance being similar to that of Case XI (Fig. 12) and Case XII (Fig. 13).

12-1-24 to 12-3-24: Therapeutic test dose was administered over the mediastinal mass amounting to 130 per cent S.U.D., with 200 kv., 1 mm. Cu.

Checkup roentgenograms made on March 2, 1925 and January 9, 1926, revealed no change. A final diagnosis of aneurysm was made.

2-10-36: Patient died. At the postmortem examination a large aneurysm of the aortic arch was found.

Case XVIII. P. G., male, aged forty. In the spring of 1935, the patient developed an osteogenic sarcoma of the right maxilla which was successfully treated by four series of supervoltage roentgen treatments and intranasal radium (Fig. 19). During 1936, he developed a gradually progressive shortness of breath. There was a history of an acute attack of rheumatic arthritis in 1924. Since then the patient has been repeatedly treated for a heart condition, although no decompensation was ever noted.

12-7-36: Physical examination revealed that the heart was enlarged. The sounds were clear and well perceptible over the right half of the heart, but they were gradually diminishing over the left half and were completely absent in the region of the apex. There were no signs of decompensation.

Roentgenogram showed a generalized enlargement of the cardiac silhouette. Because of the disproportionate cyanosis, the possibility of a metastatic process from the primary osteogenic sarcoma of the maxilla was considered. The other alternative was chronic myocarditis. Since there were no murmurs present, a valvular lesion was ruled out.

12-8-36 to 12-12-36: Therapeutic test dose was given amounting to 130 per cent S.U.D., with 500 kv., 7 mm. Cu.

Subsequent roentgenograms demonstrated no response to the irradiation. Later there was a slow, and during 1939, a more rapid, increase in the shadow of the heart as a whole (Fig. 20).

4-2-40: Roentgenogram showed very marked enlargement of the cardiac silhouette suggesting cor bovinum or aneurysm of the left auricle. However, since the sounds over the entire left half of the heart were absent, a retrocardiac dermoid, displacing the heart to the right, also had to be considered.

7-26-40: Aspiration was done and this supported the diagnosis of retrocardiac dermoid (Fig. 21).

8-13-40: Radical operation was performed by Drs. O'Brien and Tuttle, and a pedunculated mediastinal dermoid, which was just behind the heart, pushing it to the right, was extirpated.

For ten days the patient made a very satisfactory postoperative recovery, but then developed pneumonia of the right lung and died on August 24, 1940.

Postmortem examination revealed a normal heart. There was no evidence of recurrence or metastases from the former osteogenic sarcoma of the maxilla.

Comment. The most important thing in connection with this group is that the irradiation must be carried out with great care so as to avoid any injury to the normal structures. Not a few of the tumors are eventually subjected to delicate surgical interventions. The presence of adhesions within the tumor bed or fibrosis of the surrounding tissues and lungs would unnecessarily complicate matters, perhaps even jeopardizing the success of the operation. In none of our 5 cases in which the tumors were removed at intervals of from three months to ten years after the administration of the roentgen therapeutic test dose was there the slightest difficulty encountered at the time of the surgical extirpation.

CONCLUSIONS

It appears safe to conclude from the above that the application of the roentgen therapeutic test dose is of great value in

Groups I and IV and to a lesser extent in Group III. In practice, it has the following advantages:

(1) It permits a close enough initial differentiation in most mediastinal tumors so that the radiation therapy can be continued with successively adjusted doses until the course is properly concluded.

(2) If the tumor proves benign, no damage has been done to the surrounding normal structures and subsequent surgical intervention encounters no difficulties.

(3) From the standpoint of late results it was found that some of the largest and most malignant mediastinal neoplasms have completely disappeared and patients continued to live in good health for five to eighteen years after treatment. In others, death resulted within a few years from distant metastases, but without evidence of local recurrence. In the benign tumors in which surgical extirpation was successfully performed some time after the application of the roentgen therapeutic test dose, the chest soon became normal in appearance and a permanent cure of the patient was the rule.

DISCUSSION

Dr. U. V. Portmann, Cleveland, Ohio. Drs. Reynolds and Leucutia have delved into their large experience to present a very interesting subject. The applicability of "roentgen therapeutic test doses" is by no means fully appreciated either by radiologists or other physicians. The authors have chosen to limit their discussion to mediastinal tumors, yet the procedure may be used for tumors in other locations. It is gratifying that the course of mediastinal tumors following irradiation can be demonstrated so satisfactorily and spectacularly roentgenologically.

The authors have made the point, with which I agree, that "the test dose in most instances represents the maximum amount that can be safely administered." However, I am not convinced that as a routine procedure, "our aim must be to deliver to the tumor area the entire radiation within the shortest possible time." In all other respects the technique outlined is admirable. They state, "one portal is treated daily with a full skin unit dose per seance, so that the series is completed in two to six days." They consider "100 per cent S.U.D. represents 900 r given in one seance." I have had some disagreeable experiences from irradiation of some mediastinal tumors too quickly. These proved to be extremely radiosensitive types that would be included in the authors' Group I or II. The rapid disintegration following even one-third as much as 1 S.U.D. (300 r) has been followed in some cases by severe shock or toxic reactions. I favor proceeding cautiously at first, ultimately arriving at a dose equivalent to that suggested.

The authors bring up a question about the possibility of therapeutic irradiation producing sufficient fibrosis to make subsequent operations unusually difficult. I have been interested in this question and wondered if we have not been unduly concerned and even misled by surgeons. Of course it is true that improper irradiation will fibrose tissues, but let us consider dosages known to be safe and as ordinarily applied in therapy.

Inflammations and fibrous tissue formation are associated with tumors in varying degrees. These are natural responses of the organism. It may be that irradiation will *reduce* inflammation and thereby hasten the development of fibrous tissue in and about tumors which otherwise would take place naturally though slower. In all probability this reaction occurs predominantly and to the greatest degree in rapidly growing, particularly radiosensitive tumors such as would be included in the author's Group I or II. But these are not operated upon. On the other hand, inflammation is not such a prominent feature, though fibrous tissue usually is abundant and well established by natural reactions, in and about many slowly growing tumors, such as would be included in the author's Group II or III. Occasionally these tumors are attacked surgically. It is permissible to question whether irradiation, *per se*, in properly applied therapeutic test dosages would materially affect fibrous tissue present, or increase its production in or above such neoplasms. It is not always easy technically to remove tumors, from the mediastinum or other locations, even when no irradiation has been given; especially those abundantly supplied by natural reactions with fibrous connective tissue. It may be that sometimes when surgeons encounter difficulty in removing previously irradiated tumors they unjustly attribute their troubles to fibrous tissue and

adhesions produced by irradiation, instead of to the natural response of the organism.

The authors' grouping or classification of different types of mediastinal tumors according to variations in radiosensitivity is useful for differential diagnosis. It has been arranged according to their experience with 73 cases in which they have arrived at a satisfactory diagnosis in all but 8 unclassifiable cases. They placed carcinomas of the thyroid gland properly in the radioresistant group. I am sure that they did not intentionally omit substernal goiters which are so common in the Great Lakes regions.

I am sure we all agree that the material used by the authors has been well correlated and justifies their conclusions in regard to "the value of roentgen therapeutic test doses for differential diagnosis of mediastinal tumors."

ROENTGEN THERAPY OF PITUITARY ADENOMAS*

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IOWA CITY, IOWA

IT IS our desire to emphasize the efficacy of roentgen therapy of pituitary adenomas, not as an adjunct to surgery but as the procedure of choice. We shall not, however, undertake a comparison of the results obtained by the two methods of treatment, except to state that from published statistics one can expect from 32.8 to 57.5 per cent good five year results from surgery.

The first reported case treated by irradiation alone was that of Gramegna in 1909 who treated a case with only temporary improvement. Béclère in 1909 irradiated a pituitary tumor in a sixteen year old girl who continued improved when she was last heard from approximately twenty years later.[13] Since these reports, there have been many others.

In Cushing's series of 2,023 verified intracranial tumors, reported by Henderson,[11] 17.8 per cent were pituitary neoplasms. The chromophobe type constituted 77 per cent of the intrasellar tumors, the chromophile 20 per cent and adenocarcinoma 3 per cent. Basophile adenomas are rare. A fifth type of hypophyseal neoplasm described is the "mixed" adenoma which, according to Schnitker *et al.*,[16] comprises about 7 per cent of pituitary adenomas. In Vaughan's[18] series of 52 cases the yougest was eighteen years of age, the oldest sixty and the average was thirty-nine years. Most of his cases were between twenty-five and forty-five years of age.

PATHOLOGY AND CLINICAL MANIFESTATIONS

Since the chromophobe cells are nonsecretory[11] and have no known function,[2] a tumor composed of these cells produces signs and symptoms due only to its compression of adjacent secreting glandular tissue and to pressure upon neighboring structures, notably the optic chiasm[11] and hypothalamus.[2] Pressure of the adenoma upon the secretory cells of the anterior lobe of the pituitary produces manifestations of anterior lobe hypoactivity. Thus, in a child there is interference with growth and the so-called "pituitary dwarf" is the result. Hypoactivity in the adult male is evidenced by lack of energy, fatigability, decrease in libido and later by the entire disappearance of sexual desire. In the adult female, amenorrhea and sterility may be present. Due to pressure on the hypothalamus,[2] fatty deposits about the breasts and hips with consequent weight increase may be present in both sexes. The skin is dry and soft, hair tends to fall out and the basal metabolic rate is usually low.[16]

These changes, however, are so inconstant and relatively unimportant that the presence of a chromophobe adenoma is likely to go unrecognized until it has enlarged sufficiently to press upon the overlying optic chiasm.[11] When this occurs there is first impingement upon the posterior portion of the chiasm producing a defect in the superior temporal quadrants of the visual fields, and with additional pressure complete bitemporal hemianopsia results. As the process advances the nasal fields also fail and there is finally a total loss of vision. In addition to these changes, primary optic atrophy[16] and ocular palsies may be present.[10] Such disturbances in vision frequently appear early in the chromophobe type of adenoma.[16]

In contrast to the chromophobe tumor, the constitutional manifestations of the chromophilic adenoma are striking and are due (early) to hypersecretion of the anterior lobe hormone. The appearance of this tumor before closure of the epiphyses results in the so-called pituitary giant while

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acromegaly occurs if the tumor appears after the epiphyseal closure. Early symptoms consist of personality changes and may simulate hyperthyroidism. Polydipsia and polyuria are mentioned as being frequent symptoms. In the male there may be early hyperactivity of sexual function with subsequent impotence. Menstrual changes, with menorrhagia followed by amenorrhea, may occur. Visual disturbances are not so common as with the chromophobe adenoma although there may be sudden blindness due to hemorrhage in or around the tumor,[18] and visual field and sellar changes due to pressure of the tumor.

The "mixed" adenoma is manifested clinically by signs of hypopituitarism and skeletal findings of a pre-existing hyperactivity of the gland.[11] There may be, therefore, signs of both chromophobe and chromophilic adenomas in the same patient. Cushing's syndrome, or pituitary basophilism, occurs with the basophilic adenoma in which the signs and symptoms are, in both sexes, obesity limited chiefly to the face, neck, shoulders and abdomen, purplish striae of the abdomen, hypertension and arteriosclerosis, hyperglycemia and glycosuria, osteoporosis and renal calculi. In females there is hirsutism and amenorrhea; in males, impotence.[9]

Two groups of pituitary adenocarcinoma are described by Henderson in reviewing Cushing's series of pituitary tumors. One of these groups clinically behaves as chromophobe adenomas and Henderson thinks that in spite of the histopathologic interpretation, these do actually represent chromophobe adenomas rather than true malignant growths. The other group represents a true malignant neoplasm with outstanding manifestations such as trigeminal involvement and ocular palsies. Although they rarely metastasize, one case in the series showed secondary lesions in the liver at necropsy.[11]

Headache is a common complaint in the presence of hypophyseal neoplasms. Pfahler and Spackman[14] reported a series of 18 cases of which 17 had headache. This is believed to be produced by distention of the sella or by pull upon the dura and is said to be relieved when the tumor breaks through the sella.[16]

All patients suspected of having a pituiary tumor should have roentgen examination of the skull to determine the status of the sella turcica. The normal adult sella is approximately 15 mm. in its anteroposterior diameter and 10 mm. in depth. Cushing considered as significant a sella having dimensions greater than these. Basophilic adenomas rarely attain large size[11] and chromophilic tumors frequently fail to become sufficiently large to produce enlargement of the sella, although they may grow to enormous size.[18] Chromophobe adenomas, on the other hand, frequently produce sellar changes with the sella showing enlargement by depression of its floor, destruction of the posterior clinoid processes and erosion of the anterior clinoid processes. Roentgen evidence of increased intracranial pressure rarely results from the presence of intrasellar tumors.

TREATMENT

It is recognized by many authors that pituitary adenomas should be treated by roentgen irradiation. They advise that if after an adequate period of observation following roentgen therapy satisfactory response is not obtained recourse to surgery should not be delayed.[1,4,8,13,14,16,17,18] Some observers think that partial surgical extirpation should always be followed by roentgen irradiation.[11] Still other authors consider that surgery is the best treatment and that irradiation is of little benefit.[12] Cushing[3] went so far as to state in 1932 that, "So far as concerns radiotherapeusis, at least in the chromophobe adenoma, it is safe to say that it will come to be discarded. . . ." However, in reporting 187 cases of pituitary tumor in Cushing's series, Henderson[11] points out that, "prophylactic x-ray treatment given within a month or two of operation delays and probably in many cases inhibits any recurrence of tumor growth." In support of this state-

ment his results show that of 40 cases treated by surgery alone 57.5 per cent were free of recurrence at the end of five years, while of 31 treated by surgery plus irradiation 87.1 per cent showed no recurrence.

In a series of 75 cases of chromophobe adenoma reported by Schnitker *et al.*,[16] 33 were treated by surgery alone and 42 by surgery plus irradiation. The degree of improvement in each group was essentially the same although the average period of improvement was one year longer in the group which received only irradiation. In another series of 7 cases which received only irradiation, 6 showed permanent improvement, while the seventh was operated upon. In a series of pituitary tumors reported by Rand and Taylor,[15] 13, or 81 per cent, of 16 cases treated by irradiation alone were definitely improved. Pfahler and Spackman[14] reported 18 cases of pituitary tumors of which 6 were definitely improved by irradiation alone and 4 by irradiation plus surgery. Two improved following irradiation, but died following operation and 2 who were treated by irradiation because of postoperative recurrence were improved. Sosman[17] reported that 7 out of 8 cases of chromophobe adenoma shows marked improvement following roentgen therapy alone. In Dyke and Gross's[5] series of 5 cases treated by irradiation alone, all had relief of headache, 3 showed marked visual field improvement and 2 remained stationary objectively, but were subjectively improved. Dyke,[6] in following 20 cases treated by irradiation, found that (*a*) in 75 per cent general symptoms such as headache, lethargy, diplopia and fatigability were relieved; (*b*) 25 per cent showed marked improvement in vision; (*c*) in 50 per cent vision remained stationary while (*d*) in 25 per cent vision continued to decrease in spite of treatment. Failure to achieve satisfactory results in the latter he explains as probably being due to the presence of cystic tumors since about 20 per cent of pituitary adenomas show this change.

A common practice in the roentgen therapy of pituitary tumors is the administration of a relatively small dose which is repeated at intervals varying from one to two months as the progress of the case indicates. Likewise cases treated by both surgery and irradiation commonly receive relatively small doses of roentgen rays.

Sosman[17] thinks that poor results in Cushing's cases which were irradiated were due to insufficient treatment since these patients were given small doses using relatively low kilovoltage. Freyberg *et al.*,[7] in reviewing 18 cases from the literature found that every patient who received large amounts of roentgen rays was markedly improved and concluded that failure to attain good results in a patient to whom they gave only 1,600 roentgens, and in other reported cases, "might very well be explained by the fact that this treatment was not sufficiently pursued or that the dosage was insufficient." It is their impression that "much can be done for these patients if roentgen therapy in sufficient doses is persistently applied."

Concern is expressed by some authors regarding undesirable effects of irradiation. Vaughan[18] thinks that treatment should not exceed 2,700 r since even with this dose the patient may have a period of lethargy, lowered vitality and lowered basal metabolic rate, become uncomfortable and susceptible to infections. According to Sosman[17] the dangers from or following irradiation are real but infrequent and he has not observed in any of his cases brain edema which is often cited as a possible post-irradiation complication. He states that brain tissue of adults will tolerate up to 6,000 r in any one area. Other dangers mentioned by him are acute hemorrhagic cyst formation and cataracts. The production of cataracts of course is easily avoided by so directing the roentgen-ray beam that the eyes are not irradiated. The only other danger he mentions lies in the period of delay necessary to determine results, but he has not seen a patient become worse during or immediately following irradiation except those having cystic tumors.

In our own series of 25 cases we have

TABLE I

Case No.	Name	Age	Sex	Signs and Symptoms	Tumor Type	Treatment	Progress	Months Followed Result
1	C.A.	69	M	Diplopia; failing vision 4 mo.; bitemporal hemianopsia; enlarged sella; VOS 6/12, VOD 6/15 +2	Chromophobe	Oct. 1938, tumor dose 2546 r in 27 days	Visual fields enlarged 2 mo. after treatment. Unchanged thereafter. Died 12-18-39 of proved coronary occlusion	14 mo. Good
2	L.A.	43	M	Failing vision 1 yr. with blindness OS 6 mo.; occipital headache; temporal hemianopsia OD; enlarged sella	Chromophobe	Feb. 1934, 1600 r in 15 days. Dec. 1934, 2457 r in 23 days. Apr. 1935, 1931 r in 19 days. Total: 5988 r in 14 mo.	Vision improved after 9 mo. Gradually improved. Vision in blind eye returned to ¼ field	82 mo. Excellent
3	W.B.	44	M	Enlarging hands and feet 4–5 yr.; acromegalic features; sella enlarged; B.M.R. +40%; visual fields normal	Chromophile	Nov. 1934, 1200 r (air) to each of 5 portals in 22 days	In 3 mo. hands and feet felt smaller and patient better; 57 months later B.M.R. +14%; facial expression unchanged	73 mo. Excellent
4	C.E.C.	30	M	Failing vision to shadow perception OS for 18 yr.; 42 lb. increase weight; sella enlarged; VOS blind, VOD temporal field loss	Chromophobe	Partial surgical removal 2 yr. before irradiation. May, 1931–May, 1932, 4000 r (air) with 200 kv., 0.5 mm. Cu, 1.0 mm. Al, and 5400 r (air) 130 kv., 0.25 mm. Cu. 1.0 mm. Al	Improved following operation but blind 2 yr. after irradiation field larger; 115 mo. vision showed no further gain	115 mo. Excellent
5	C.D.	9	M	Failing vision progressing to blindness 5 mo.; light perception only; headaches	Chromophobe	May, 1934, tumor dose 1367 r	Vision improved rapidly. After 6 mo. craniotomy showed no tumor; 65 mo. after treatment vision normal, no headache. Growth and weight normal	79 mo. Excellent
6	M.D.	70	F	Blurred vision 3 yr.; occipital headache; enlarged sella; bitemporal hemianopsia	Chromophobe	May, 1939, 1518 r in 13 days. Nov., 1939, 1766 r in 17 days. Total: 3284 r in 6 mo.	Divided dosage because of age. 3 mo. after 2nd course visual acuity improved. Fields unchanged; 21 mo. after 1st course able to write but vision not improved	21 mo. Good
7	G.H.	46	M	Blind OD 21 mo. Failing vision OS 3 mo. Mentally dull; B.M.R. −31%; sella enlarged	Chromophobe	Aug., 1934, 1940 r in 16 days. Nov., 1934, 1523 r in 14 days	Visual field OS smaller after 1st course. Visual field OS larger 6 mo. later. B.M.R. −24%; Improved for 19 mo. 52 mo. died suddenly. Autopsy showed 2×4 cm. sellar tumor	52 mo. Poor
8	R.H.	50	M	Failing vision OS 12 mo. Failing vision OD 3 mo. Bitemporal hemianopsia; enlarged sella	Chromophobe	Oct., 1939, 2990 r in 37 days	3 mo. after therapy vision improved; 15 mo. still further improvement	15 mo. Excellent
9	H.H.	62	F	Blurred vision; dizziness 3 yr.; coarse hands and feet; visual fields contracted; heart failure	Chromophile	Oct., 1932, 3222 r in 23 days	Died 1 mo. after therapy	1 mo. Poor
10	E.J.	28	F	Wt. increase of 130 lb. in 10 yr. Enlarged sella; no visual disturbance; frequent headache	Chromophobe	March, 1934, 1000 r in (air) to each temporal. Sept., 1934, repeated above	Headache relieved for 81 mo. after 1st course	8 mo. Excellent
11	J.K.	68	M	Failing vision 5 yr.; headache; bitemporal hemianopsia; enlarged sella	Chromophobe	Sept., 1936, 3148 r in 23 days. Further treat- elsewhere 1937–1938, amount unknown	42 mo. after treatment, no headaches, vision fair. Died of cerebral accident	42 mo. Good

Table I—*Continued*

Case No.	Name	Age	Sex	Signs and Symptoms	Tumor Type	Treatment	Progress	Months Followed Result
12	L.K.	35	M	Failing vision; headaches 18 mo. Complete temporal hemianopsia os; clinoids thin	Chromophobe	Oct., 1939, 3043 r in 48 days	Visual acuity improved, fields unchanged. Headaches improved	23 mo. Good
13	F.L.	48	F	Failing vision 3 yr.; headache. Ptosis right lid; enlarged sella; fields contracted	Chromophobe	Jan., 1939, 1899 r in 21 days	Patient died 4 mo. after treatment	5 mo. Poor
14	B.M.	36	F	Increasing wt. 13 yr.; headache; enlarged sella; temporal field cut	Chromophobe	Dec., 1931, 819 r in 7 days	Good vision, eyes "weak." "Unable to see to thread needle"	108 mo. Excellent
15	J.P.	11	M	Increasing obesity 3 yr.; headache, sleepiness; rt. homonymous hemianopsia	Chromophobe	Sept., 1937, 2866 r in 29 days	Rapid improvement in vision. Loss of wt. and gain in height. No headache. With original class in school	40 mo. Excellent
16	J.H.P.	30	M	Headache; failing vision; bitemporal hemianopsia; enlarged sella	Chromophobe	June, 1936, 2576 r in 21 days	In 3 mo. fields normal	56 mo. Excellent
17	C.R.	35	M	Headache and blurred vision for 1 yr. Bitemporal hemianopsia. Enlarged sella	Chromophobe	June, 1935, 1706 r in 16 days. Jan., 1936, 2152 r in 18 days	Gradual improvement in vision until 6 mo. post-irradiation, it was normal	68 mo. Excellent
18	C.R.	40	M	Bitemporal hemianopsia 1 yr.; headache	Chromophobe	Oct., 1937, 2510 r in 29 days	Loss of headache, vision definitely but slightly improved	38 mo. Excellent
19	B.S.	39	M	Failing vision 2 yr.; almost blind os 1 yr.; headache 1 yr; bitemporal hemianopsia; enlarged sella	Chromophobe (cystic)	Jan., 1938, 2047 r in 29 days. May, 1938, cystic tumor partially removed	Visual fields improved postoperative	36 mo. Poor
20	A.S.	46	F	Blurred vision and headache 5 yr. vos 6/6–1; temporal hemianopsia os unable to obtain field od; enlarged sella	Chromophobe	April, 1933, 3120 r in 12 days	Loss of headache and gradual improvement in vision. Glasses only for reading	92 mo. Excellent
21	V.S.	58	F	Bitemporal hemianopsia; enlarged sella	Chromophobe	Nov., 1936, 2129 r in 34 days	Slightly enlarged fields	49 mo. Excellent
22	J.T.	57	M	Failing vision, diplopia 3 yr. vod 6/24 vos count fingers at 2 ft.; enlarged sella	Chromophobe	Jan., 1933, 3820 r in 23 days	At 74 mo. "sees large print at 5 ft." At 8 yr. vision worse	96 mo. Poor
23	A.T.	35	F	Failing vision 1½ yr.; amenorrhea 6 yr.; bitemporal hemianopsia; enlarged sella	Chromophobe (cystic)	July, 1937, 3337 r in 27 days. Nov., 1937, cystic tumor removed surgically	Worse after irradiation; much improved 37 mo. postoperative	41 mo. Poor
24	F.Y.	54	M	Diplopia 4 mo.; ptosis 2 mo.; lesion of 3d and 4th cranial nerves; ophthalmoplegia; markedly enlarged sella; visual fields contracted	Chromophobe	March, 1932, 4277 r in 23 days	Fields normal 1 yr. post-irradiation. Recalcification of sella in its enlarged form. 8 yr. 9 mo. after treatment visual fields normal	105 mo. Excellent
25	W.A.	62	M	Headache 8 mo.; diplopia 3 mo.; ptosis 1 mo.; ophthalmoplegia; destruction of sella and of anterior portion of foramen magnum	Chromophobe	Aug.-Oct., 1939, 3831 r in 47 days	Headache improved. No ptosis of right upper lid. Felt generally better	20 mo. Good

found that irradiation of the skull in patients with arteriosclerosis and hypertension must be carried out cautiously as they may undergo mental deterioration probably as a result of the treatment.

ANALYSIS OF CASES

This group of cases of pituitary adenoma consists of 25 patients all of whom have been followed for over a year or until their death. In addition to these 25 patients we have treated 9 patients with pituitary adenoma whom we are not including in this report because they have been followed for less than one year. In the period between May, 1931, and June, 1941, we have seen in all 41 cases, 34 of whom have received roentgen therapy while 6 received no treatment. Of this total number 31, or 75.6 per cent, were of the chromophobe type, 9, or 21.9 per cent, chromophile and 1, or 2.4 per cent, basophile. None was diagnosed as the "mixed" type. Five were verified by surgery while all others were diagnosed clinically. Three cases, or 7.3 per cent, were found at operation to be cystic.

Twenty-two, or 53.6 per cent, of the 41 patients were males, 19, or 46.3 per cent, females. The average age was forty-three years nine months. The oldest was seventy years and the youngest nine years. Thirty-five per cent were in the age group of fifty-one to seventy inclusive, 45 per cent from thirty-one to fifty inclusive, 15 per cent from twenty-one to thirty inclusive, and 5 per cent from one to eleven inclusive.

The result in each case treated is recorded as "excellent," "good," or "poor." Those who have maintained improvement are considered as "excellent" results, those with an arrest of the disease as "good," and those with progression of the disease as "poor." The pertinent data on these cases are recorded in Table 1.

One patient (Case 4) was treated because of recurrence two years following partial removal and now, eight years and seven months after irradiation, he has maintained his improvement. It is interesting to note that this patient was operated on by Dr. Cushing, who directed the patient to us when signs of recurrence appeared. Case 5, a nine year old boy, was explored six months after roentgen therapy even though he had obtained definite improvement following this treatment. No tumor was found and the patient continued to improve. Now, six years and seven months after irradiation he has normal vision, has grown normally and does very well in school. Case 7 died rather suddenly four years and four months after roentgen therapy. His tumor was the chromophobe type and his basal metabolic rate was −31 per cent. Six months after therapy it was −24 per cent. Just prior to his death he was blind in the right eye and vision in the left eye was very poor. Autopsy done elsewhere showed a pituitary tumor measuring 2 by 4 cm. Case 9 died one month after being dismissed from the hospital. Hers was a chromophilic adenoma and her basal metabolic rate was +32 per cent. No post-irradiation basal metabolic rate was determined. At the time of admission her heart was enlarged and in failure. Although we believe her death was due to cardiac disease, we have considered the result of our treatment as poor. Case 13 became disoriented during treatment so not all of the planned course was given. Her course was rather stormy and she died four months after treatment. This patient had hypertension and we think that her reaction to treatment was due to a combination of vascular change and irradiation reaction in the brain. Case 15, an eleven year old boy with a chromophobe adenoma, on admission was lethargic and mentally retarded, his vision was failing and he was becoming progressively obese. At the completion of roentgen therapy the vision was definitely improved. Within the next three years and four months the vision returned to normal and he lost in weight but gained in height. Whereas he had been mentally sluggish and his illness necessitated an absence of one year from school, he has caught up with his original class and does very well in his

school work. Case 19 showed no change in the visual fields, but had decreased visual acuity three months after irradiation. Craniotomy was done and the sellar tumor was found to be cystic. Case 23, similar to Case 19, had further constriction of visual fields four months after irradiation and at operation the tumor was also found to be cystic. These two cases demonstrate the failure of response in tumors showing cystic change. Case 25 when first seen had complete ophthalmoplegia and marked destruction of bone about the basilar portion of the sphenoid bone and sella turcica. Severe headaches were relieved following treatment but four months later he again had severe headaches, some nausea and vomiting and the bone lesions were unchanged. Because of the extensive bone destruction we at first thought this case represented a malignant neoplasm of the pituitary, but since he was still alive one year and eight months after roentgen therapy, and also had relief of his headaches, the tumor was then considered as a chromophobe adenoma.

Summarizing the results in the 25 cases followed for at least twelve months, or until death, there are 14, or 56 per cent, considered to be excellent, 5, or 20 per cent, good and 6, or 24 per cent, poor.

Many reports in the literature indicate that chromophobe tumors do not respond well to irradiation. Langer[12] states that "this type of tumor can be practically excluded from treatment by the roentgenologist, except when serious headaches and eye symptoms are present and operation is refused. An attempt to ameliorate the condition temporarily with heavy roentgen irradiation may then be justified." Our experience indicates that chromophobe tumors do respond well and we wish to emphasize that 76 per cent of our cases had either excellent or good results. We attribute this to the relatively heavy doses we have employed.

TECHNIQUE OF THERAPY

Where possible the amount of irradiation is recorded as that received by the tumor. All but one of the cases were treated with 200 kv., with filtration of either 0.5 mm. copper or Thoraeus filter (0.4 mm. Sn, 0.25 mm. Cu, 1.0 mm. Al), at 50 cm. distance. The half-value layer with Thoraeus filtration is 2.0 mm. Cu, and the effective wave length 0.135 Å. With 0.5 mm. Cu filtration the half-value layer is 0.95 mm. Cu and the effective wave length is 0.16 Å. Each of two portals is given 200 roentgens daily as measured in air, with the exception that only one area is treated the first day. We do this in order to keep to a minimum any brain reaction that may result from the first treatment. If none occurs, we proceed with the treatment as outlined. In most cases therapy was carried out through five portals—one to each temporal, frontal, vertical and occipital region. In some the size of the portal was 6 by 8 cm., some 10 by 10 cm. and in some a 5 cm. round cone was used. Our present technique consists of five 6 by 8 cm. portals about the head. Each of two portals is given 200 r daily, using 200 kv., Thoraeus filtration, 50 cm. distance, until each has received 1,800 r, or a total of 9,000 r, measured in air. This treatment causes temporary epilation but in our experience this has never become permanent.

SUMMARY AND CONCLUSIONS

A review is given of the types of intrasellar tumors and their clinical manifestations. Results obtained elsewhere by roentgen therapy of such tumors are cited. Twenty-five of our cases receiving roentgen therapy and followed for over one year, or until death, are reported. Twenty-two of these 25 cases were treated with irradiation only and two who first received roentgen therapy and failed to benefit were found later to have cystic tumors. The poor response in these two demonstrates the inadequacy of roentgen therapy in this type of tumor. Of the 25 patients treated with irradiation, one being treated because of postoperative recurrence, excellent results were obtained in 56 per cent, good results

in 20 per cent and poor results in 24 per cent of these cases.

The chief criteria used in judging progression or regression of the disease are the visual field changes and loss of headache. The success or failure of therapy must be judged not on survivals as in malignant neoplasms, but on preservation or restoration of vision and the general well-being of the patient.

This study indicates that irradiation is the treatment of choice and that this should be carried out with relatively heavy doses. If, however, the patient shows evidence of progression of the disease in a period of three to four months, surgical exploration should be carried out because of the likelihood that the tumor is cystic.

In employing relatively large doses of radiation we have encountered untoward effects only once. This was in a patient with arteriosclerosis and hypertension who developed mental deterioration. These changes we attribute to the effects of irradiation on arteriosclerotic cerebral vessels associated with hypertension.

REFERENCES

1. BAILEY, P. Results of roentgen therapy on brain tumors. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *13*, 48–53.
2. BOYD, WILLIAM. Text Book of Pathology. Lea & Febiger, Philadelphia, 1938, p. 710.
3. CUSHING, HARVEY. Intracranial Tumours. Charles C Thomas, Springfield, Ill., 1932, p. 69.
4. CUTLER, MAX, and BUSCHKE, FRANZ. Cancer: Its Diagnosis and Treatment. W. B. Saunders Co., Philadelphia, 1939, pp. 609–612.
5. DYKE, C. G., and GROSS, S. W. Roentgenotherapy of pituitary tumors. *Bull. Neurol. Inst. New York*, 1931, *1*, 211–228.
6. DYKE, C. G. Roentgen ray treatment of tumors of the brain and skull. *Bull. New York Acad. Med.*, 1935, *11*, 392–402.
7. FREYBERG, R. H., BARKER, P. S., NEWBURGH, L. H., and COLLER, F. A. Pituitary basophilism (Cushing's syndrome). *Arch. Int. Med.*, 1936, *58*, 187–212.
8. GRANT, F. C. Surgical treatment of pituitary adenomas. *J. Am. M. Ass.*, 1939, *113*, 1279–1282.
9. HANSSEN, P. Cushing syndrome. *Acta med. Scandinav.*, 1936, *89*, 517–525.
10. HARE, C. C., and DYKE, C. G. Roéntgen therapy of pituitary tumors; report of 20 cases. *Arch. Ophth.*, 1933, *10*, 202–225.
11. HENDERSON, W. R. Pituitary adenomata; follow-up study of surgical results in 338 cases (Dr. Harvey Cushing's series). *Brit. J. Surg.*, 1939, *26*, 811–921.
12. LANGER, HEINZ. Roentgen therapy in diseases of the glands of internal secretion. In: Clinical Roentgen Therapy. E. A. Pohle, Editor. Lea & Febiger, Philadelphia, 1938, pp. 666–667.
13. PFAHLER, G. E., and SPACKMAN, E. W. Roentgen therapy in pituitary tumors. *Am. J. Ophth.*, 1931, *14*, 796–807.
14. PFAHLER, G. E., and SPACKMAN, E. W. Further observations on the roentgen treatment of pituitary tumors. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 214–226.
15. RAND, C. W., and TAYLOR, R. G. Irradiation in the treatment of tumors of the pituitary gland; report of 23 cases. *Arch. Surg.*, 1935, *30*, 103–150.
16. SCHNITKER, M. T., CUTLER, E. C., BAILEY, O. T., and VAUGHAN, W. W. Chromophobe adenomas of pituitary. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *40*, 645–659.
17. SOSMAN, M. C. Roentgen therapy of pituitary adenomas. *J. Am. M. Ass.*, 1939, *113*, 1282–1285.
18. VAUGHAN, W. W. Place of irradiation in acromegaly. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *40*, 660–668.

DISCUSSION

DR. MERRILL C. SOSMAN, BOSTON. Drs. Kerr and Cooper have presented very definite evidence to the effect that roentgen therapy is the method of choice in the treatment of pituitary adenomata. This confirms the findings of our group in Boston, previously reported before this Society in 1935 and 1936. In analyzing the results in such a series of cases it is important always to keep in mind that five year survivals are of no importance, as most of these patients would live ten, fifteen or even twenty years without any form of treatment. We are dealing not with a malignant metastasizing tumor but with a benign adenoma, and the criterion by which we must judge our results is not survival, but the restoration of vision, the alleviation of symptoms, and the ability to work or to live normally. In females the return of normal menstruation is an undoubted index of restoration of glandular function. In males, however, the return of libido and potentio is not reliable, complicated as it is by somatic and psychic factors not under control of the pituitary gland.

Our tendency has been to increase the dose of irradiation by prolonging the period of treatment, but we still do not give as large a total dose as the 9,000 r reported by Dr Kerr. Undoubtedly the results have been better with larger doses in our series and perhaps we should increase them still more as we have done in so many other fields of radiation therapy.

There is one surprising feature in this series, and that is the 2 patients under twelve years of age, one nine years old and one eleven years of age. In our series we had none under twelve and I was inclined to think that this could be used as a differential point in diagnosis. I would like to know more about those two patients.

The other new point in this presentation is the charge that roentgen therapy was the cause of the mental deterioration in Case 15, the patient with hypertension and disorientation. We all agree that cystic pituitary adenomata do not respond well to irradiation, but Henderson has shown that even in those cases recurrences are delayed or prevented by postoperative roentgen therapy. I do not believe, however, that daily doses of 200 r to each of two portals could affect the arteriosclerotic arteries of a hypertensive individual.

With these two exceptions I would concur with all that has been presented, compliment Drs. Kerr and Cooper on their excellent work, and warn you all that these patients should be seen and examined thoroughly at least semiannually as recurrences or regressions are often insidious as well as dangerous to your patients' vision and your final results.

Dr. Kerr (closing). I appreciate very much Dr. Sosman's discussion. I think the important thing to remember is that we are probably producing damage to the brain through the doses which we are using. So far, however, the changes mentioned have not been of clinical significance. The point has been brought out that perhaps in our own work we are exceeding what is necessary, and this point is well taken, because although we are dealing with a tumor, we are not dealing with a malignant tumor. On the other hand, we have to balance what will become of the patient if we don't control this pituitary tumor, even though it is benign, and what will become of the patient if we do control it; so that although I think perhaps we are using slightly heavier doses than are necessary, I believe our error is on the right side.

I am sure that we injure far fewer patients in treatment of pituitary—benign pituitary—tumors than we injure through over-irradiation, though in one case I am sure that our irradiation was the cause of death.

It might be just as well, therefore, if we would reduce our dose from a total of 9,000 roentgens to perhaps 7,500 r. We don't, of course, measure our dose as an air dose primarily but use it as an indication of what we are getting in the tumor. In our published tables the dosage we give will be expressed as a tumor dose, and we find we have good results when this tumor dose varies from 2,000 r to about 3,200 r, so that if we can keep generally within that range, I think perhaps we will give the patient the best type of irradiation.

THE RADIATION TREATMENT OF CEREBELLAR MEDULLOBLASTOMA

REPORT OF THIRTY-ONE CASES*

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PHILADELPHIA, PENNSYLVANIA

The first cerebellar tumor irradiated in the Department of Radiology of the Hospital of the University of Pennsylvania was treated by Dr. Henry K. Pancoast[24,25,26] in 1914. This was probably one of the earliest cerebellar tumors treated in this country.† Since then we have irradiated 51 patients with cerebellar tumors of whom 31 were known to have had histologically verified medulloblastoma. Enough time has elapsed following the treatment of these patients for us to present our data. In addition, we shall review the general problem concerning the use of radiation in the treatment of cerebellar medulloblastoma.

PATHOLOGY

Medulloblastomata cerebelli usually arise over the roof of the fourth ventricle.[2,15] As a rule they develop from embryonic rests,[5,7] as central intracerebellar lesions. In children the lesions are usually in the midline. In adults they may lie in one of the lateral hemispheres.[8]

Grossly these neoplasms are made up of friable grayish tissue which appears to be fairly well circumscribed microscopically, though histologic study invariably reveals invasion of the surrounding tissue.

A discussion of the histopathologic characteristics of medulloblastoma lies beyond the scope of this paper. These have been described by Bailey and Cushing[2] and others.[5,7,8,15] Suffice it to say that the tumors are made up of rapidly growing, undifferentiated cells, resembling round cell sarcoma. Mitotic figures are frequent. There is little or no stroma; the tumors may be considered relatively vascular. Usually there is no architectural arrangement of the cells though pseudorosettes may be found.

Medulloblastoma frequently extends to other parts of the brain and spinal cord. Indeed death may be due to these extensions rather than the primary growth (Fig. 1 and 2). Metastases have been found in the pia-arachnoid of the brain and cord and in the ventricles. In the ventricles the implants vary in size from nodules easily seen grossly to microscopic nests of cells.[6] In the spine, metastases usually develop as sheaths of firm white tumor tissue which encircle the cord in the subarachnoid space. The lesions may be single or multiple and frequently lie close to the roots of the spinal nerves.

Nelson[22] reported 2 patients with bone metastases. In one patient the sternum was involved, in the second several vertebral bodies.

In 1928 Pendergrass and Wilbur[28] reported the presence of bone metastases in a patient with a cerebellar tumor. It was suggested that the bone lesion might have been secondary to the cerebellar growth. The possibility that no relation existed between these two lesions was also considered. A review of the findings in this patient indicate that the patient had a neuroblastoma with disseminated metastases.

How medulloblastoma spreads beyond the cerebellum remains unexplained. The presence of tumor nodules in the ventricles and subarachnoid spaces suggests that the tumor may be disseminated by the cerebrospinal fluid.[6] The apparent predilection

† The patient, operated upon by Dr. C. H. Frazier, had a "gliosarcoma," which was irradiated at irregular intervals with radium. When last heard from in 1921 she was clinically well. Whether this tumor was an astrocytoma, medulloblastoma, or some other tumor type could not be determined as the histologic sections were destroyed.

* From the Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania. Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

for these lesions to develop in the caudal portions of the cord and on its dorsal aspect seems to lend support to this explanation which implies that gravity plays a considerable part in the distribution of the metastases.

Winkelman and Eckel[35] believe that the perivascular lymphatics of the brain and cord act as an avenue through which the tumor may be disseminated. They call attention to the fact that there exists in the peri-

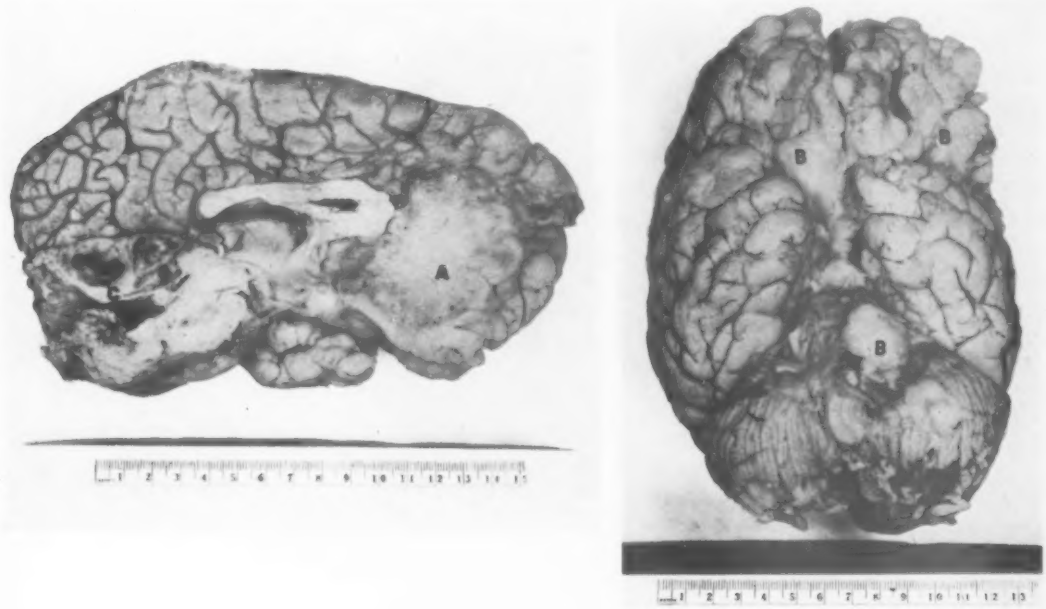

Fig. 1. Cerebellar medulloblastoma with diffuse metastasis throughout the brain. *A*, large metastatic area involving the frontal lobe. *B* indicates multiple metastatic foci in the base of the brain. *C*, site of the primary tumor where residual evidence of disease may still be seen.

vascular spaces a slow flow of current which is directed toward the subarachnoid space and which could assist in the spread of tumor cells. The authors also assume that metastases might develop as the result of direct extension along these lymphatics.

CLINICAL CONSIDERATIONS

The outstanding symptoms in patients with medulloblastoma are headache, vomiting, and ataxia. The headaches are first irregular and intermittent but gradually increase in frequency to become constant and severe.[18,20,29] Morning vomiting, usually without nausea, also occurs early and is probably a sign of medullary irritation.[5] As the compression increases dysphagia, drooling and staggering while walking gradually develop. Visual disturbances such as diplopia and diminished vision are common. Ophthalmoscopic examination of patients with these symptoms almost invariably reveals choking of the optic discs. In addition, a rapid increase in the circumference of the head has been noted.

In children many of these signs and symptoms may be mimicked by gastrointestinal disorders or infections of various types.[20,21] Indeed it is not unusual for roentgenologists to be asked to do a gastrointestinal study in these individuals. An examination of the optic discs, with the ophthalmoscope, is of inestimable value in differentiating between the less serious illnesses and cerebellar tumors. It must be remembered, however, that in adults where the tumor is frequently situated laterally, increased intracranial pressure may develop late. In the latter group the pressure syndrome may be minimal, the symptoms suggesting an early angle tumor rather than

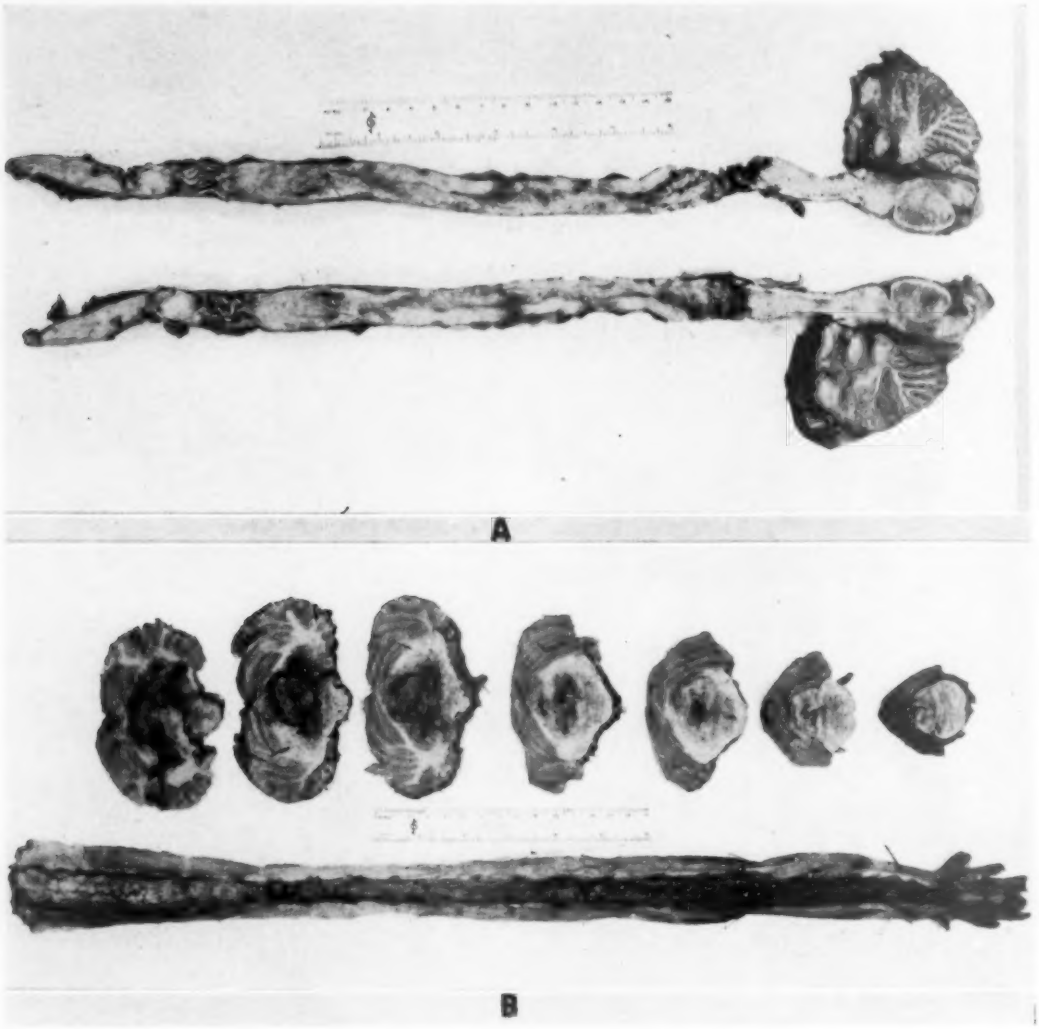

Fig. 2. *A* and *B*, spinal cords taken from two patients with cerebellar tumors. They demonstrate the disseminated spinal metastasis which frequently develops.

a cerebellar medulloblastoma. It must also be remembered that marked increased intracranial pressure with internal hydrocephalus due to other intracranial lesions, such as suprasellar growths, may produce symptoms suggesting medulloblastoma.

ROENTGENOLOGIC CONSIDERATIONS

Generally patients with cerebellar medulloblastoma reveal roentgen evidence of increased intracranial pressure. The changes may be slight or quite marked, depending on the size of the lesion, the length of time it has been present, and the presence or absence of a ventricular block.

Early, the dorsum sellae may look slightly ragged or thin on its posterior surface. In more advanced cases the posterior clinoid processes disappear and the dorsum becomes narrowed and pointed. Later the dorsum may disappear entirely. The floor of the hypophyseal fossa shares slightly or not at all in the bone atrophy, whereas the sella may become broad in the sagittal direction. In addition, the anterior clinoid processes may become thin and pointed.

The general increased intracranial pressure, induced by prolonged ventricular block, frequently results in atrophy of the inner table of the calvaria with an appear-

ance of convolutional atrophy. The skull, especially in young individuals, is apt to become thin and the sutures more prominent, or separated. It is noteworthy that patients with marked convolutional atrophy and widening of the sutures present fewer sellar changes than do patients in whom the former changes are not observed. The sellar changes are probably secondary to transmitted pulsations from the third ventricle. If a dilated third ventricle is not in position to transmit its pulsations to the region of the hypophysis, sellar changes may not develop.

The presence of the roentgen signs of increased intracranial pressure alone is of little value in tumor localization. Lesions in the region of the third ventricle and midbrain notoriously produce the same general roentgen picture. It becomes necessary, therefore, to resort to cerebral pneumography for more accurate information as to the tumor site. The intracranial tension being elevated in these patients, ventriculography must be employed.

The ventriculographic signs of cerebellar lesions may be listed as follows:

1. Dilatation of the lateral ventricles, symmetrical or slightly asymmetrical in type.
2. Uniform enlargement of the ventricles. Occasionally the ventricular outline is notched or wavy. The cause for this irregular contour is not known. It may be due to resistance offered by some parts of the brain (vessels) to dilatation.
3. The anterior horns of the lateral ventricles are generally more dilated than the inferior horns.
4. The foramina of Munro are dilated.
5. The third ventricle is dilated but with the preservation of the supraspinal recess.

RADIATION THERAPY

In reviewing the literature concerning cerebellar medulloblastoma an attempt was made to tabulate most of the radiotherapeutic techniques and end-results reported by others. It was hoped that this summation might prove valuable in determining the proper course of treatment to be carried out in these lesions. Such wide variations in radiation technique were found that a detailed analysis proved impractical. Only general therapeutic principles seemed justifiable, namely:

1. The site of the primary cerebellar tumor should be irradiated either (*a*) before, (*b*) during, or (*c*) after surgery, and
2. Proper treatment implies irradiation of the entire cerebrospinal axis in addition to the cerebellum.

1(*a*). In 1936 Cutler, Sosman and Vaughan[8] presented strong arguments in favor of the radiation treatment of suspected cerebellar medulloblastoma without surgical confirmation or decompression. They called attention to the high immediate surgical mortality (25 per cent) in these patients which could be avoided if surgery were omitted and radiotherapy resorted to instead. The expense of the surgical procedures and the paucity of competent neurosurgical centers also motivated their choice. The authors accepted the charge that such a course would be considered unscientific but believed that in selected cases the best interests of the patient were served when surgery was omitted. Indeed their limited data suggested that the results were just as good with radiotherapy alone as when given following craniotomy.

Whereas Cutler, Sosman and Vaughan advised irradiation without decompression in selected cases, they call attention to the importance of close cooperation between neurosurgeon and radiologist when it is used. The procedure is dangerous and unless diligent care is taken to avoid post-irradiation swelling of the cerebellar growth, death may ensue. To this end, very small daily exposures were used and dehydration resorted to.

We have never treated a suspected cerebellar medulloblastoma with irradiation alone. Certainly we should not hesitate to do so under unusual circumstances. Until more is known concerning the latter method of treatment we shall continue to use ir-

radiation after decompression, for two reasons. First, because the radiotherapeutic procedures are less hazardous after operation and decompression, and second, to avoid the expense, wasted effort, and the embarrassment of irradiating the entire cerebrospinal axis in patients whose lesion proves to be an astrocytoma, angioma, ependymoma, tuberculoma or arachnoiditis in the posterior fossa, or a tumor elsewhere in the brain simulating a cerebellar medulloblastoma. Indeed we have seen a patient with a sphenoidal sinus disease in whom the clinical picture of a cerebellar tumor disappeared after the sinus was drained (Fig. 3).

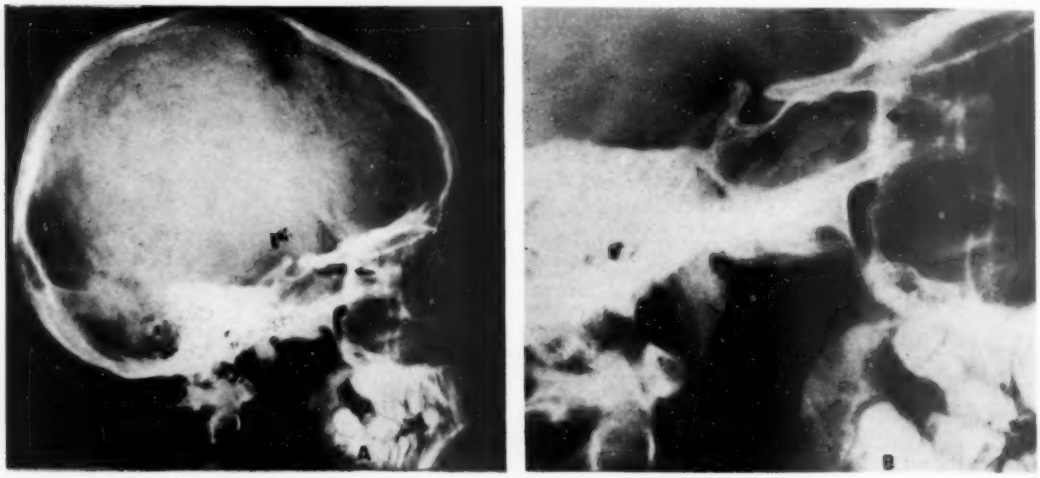

Fig. 3. *A*, roentgenogram of a patient suspected of having a cerebellar tumor. The lateral film of the head was made in the erect position and reveals fluid level in the sphenoid sinus. This fluid level is better seen in the closeup examination in *B*. Drainage of the sphenoidal sinus resulted in complete relief of the cerebellar symptoms. The patient has remained well.

1(*b*). There have been only a few clinics in which radiation has been delivered to a brain tumor through the open wound either in the form of radium, radon, or roentgen rays.

In 1922, Pendergrass, Hayman, Houser and Rambo[27] investigated the effect of radium on the normal brain and spinal cord. Working with dogs, the authors concluded that it was not safe to give enough interstitial radium to destroy an entire brain tumor without destroying normal brain tissue. This was especially true in the spinal cord where topical as well as interstitial radium proved harmful. Their evidence[27] indicated that it was not safe to exceed a total of 1,400 milligram-hours of radium when the element was placed in contact with the dura and filtered through 0.4 mm. of platinum. The authors recommended implanting radium during operation in small, accessible tumors only. In their opinion postoperative external irradiation, using a fractionated and cross-fire technique, was much to be preferred.

Davis and Cutler[9] recently reported that the ideal form of radium therapy was that which made use of weak radium needles which were adequately filtered and uniformly distributed throughout the tumor. They found that when the treatment period was extended to 120 to 168 hours the tumor could be favorably affected without destroying normal brain tissue. The number of patients in whom this procedure was carried out was too few to permit adequate evaluation of the method.

Elsberg, Davidoff and Dyke[11] irradiated patients with brain tumors through the open head wound. To obviate moving the patients these authors had a shock-proof, high voltage therapy stand and generator installed in the operating room where pa-

tients could be treated in the position of operation. The entire exposure was given at one sitting. Of the 18 patients reported, 5 died from twelve hours to eleven days after treatment. The authors concluded that the fatalities were not attributable to their radiotherapeutic technique.

We treated 2 patients with cerebellar medulloblastoma in this manner several years ago. Both patients died within twenty-four hours after treatment with 2,000 r delivered in twenty minutes.* Whether these patients were operative or radiotherapeutic mortalities could not be decided but this form of irradiation has never been repeated. The added risk of irradiating the brain during the operation seemed unwarranted, especially when a comparable tumor dose could be delivered by a postoperative fractionated cross-fire technique.

1(*c*). Most radiologists agree that cerebellar medulloblastoma is best irradiated postoperatively. The period between operation and treatment varies. Brody and German[5] wait two weeks. We prefer an interval of four to six weeks before starting radiation therapy. Patients are usually much stronger after this interval and tolerate radiation more satisfactorily. Furthermore, there is the theoretical consideration that the patient's inherent resistance to the tumor, a factor too frequently overlooked, is at a higher level after he has completely recovered from the operation. This may serve to enhance the radiotherapeutic effect upon the tumor and its extensions. Whether small nests of tumor cells, scattered during operation, are more radiosensitive when treated immediately after operation than later is unknown. If *in vitro* and *in vivo* experiments may be applied to this problem one should anticipate greater response to radiotherapy in implanted tumors than in tumor cells floating free in the subarachnoid spinal fluid.

The lack of uniformity in radiotherapeutic techniques reported in the literature has been commented upon previously. Indeed many authors have failed to record their method of treatment. Brody and German[5] used four portals over the head and three over the spine. Each portal was given 50 per cent of an erythema dose on successive days until all seven portals had received about 50 per cent of an erythema dose. Following this the exposure over each area was brought up to 100 per cent in a period of two weeks. The entire course was repeated at three month intervals.

Cutler, Sosman and Vaughan[8] gave 200 r per day to the cerebellar area and 300 r to each side of the head, covering all portions of the brain and its fluid pathways, until a total of 800 r was given to the cerebellum and 600 r to each side of the head. Then 300 r per day was delivered to the spine until each spinal area had received 600 r. The treatment to the cerebellum was repeated in six weeks. Two months later the entire first course was again directed into the cerebrospinal axis. The cerebellar area alone was again treated three months later and the entire original course repeated after three more months. Six months later the last session was again repeated. Thus Cutler, Sosman and Vaughan delivered to the surface areas of the cerebellum 4,800 r, the lateral aspects of the head 2,400 r, and each spinal area 2,400 r in a period of about fifty weeks. Brody and German, and Cutler, Sosman and Vaughan used high voltage radiation.

The radiotherapeutic technique employed in our department will be discussed below.

2. The importance of irradiating the cerebrospinal axis in patients with medulloblastoma is now well recognized. Indeed Dyke[13] has stated that he knows of no patient with spinal metastasis who had received adequate spinal irradiation. Techniques for this procedure have been recorded by numerous authors.[5,8,12,13,30,33] There exists no unanimity of opinion, however, as to the total amount of radiation necessary to prevent the development of metastasis or implants.

In most instances the total amount of radiation directed into the cerebellum is

* High voltage radiation, filtered through an added filtration of 0.5 mm. Cu + 2 mm. Al, at 35 cm. target-skin distance.

much higher than that which is used over the cerebrospinal axis. Thus Brody and German[5] delivered 2 S.E.D. to the cerebellum and 1 S.E.D. to the remaining portions of the cerebrospinal axis, a two to one ratio which was also observed by Cutler, Sosman and Vaughan.[8] This difference in exposure implies that most radiologists either recognize a difference in the radiosensitivity of the primary and secondary growths or they are afraid of administering too much radiation to such a large area of the body.

The routine irradiation of the cerebrospinal axis in cerebellar medulloblastoma was once regarded with considerable concern because of the gliosis observed in heavily irradiated cases. It is now well recognized that gliosis develops only when tumor nodules are present and does not occur when healthy nerve tissue is irradiated.[1] It must be remembered, however, that excessive irradiation can damage not only healthy cerebrospinal structures but other tissues as well.

TECHNIQUE

The plan of treatment in the Department of Radiology of the Hospital of the University of Pennsylvania has changed several times since Dr. Henry K. Pancoast first started to irradiate cerebellar tumors about twenty-seven years ago. Until 1928–1929 the cerebellum alone was treated. Soon thereafter, the spine was included in the therapeutic scheme. It was not until 1936–1937, however, that the cerebrum was routinely included.

The physical characteristics of the radiation employed have also changed during these years. Prior to 1923 radium was used almost entirely. Multiple 1¼ inch square portals were distributed over the head in order to cross-fire into the tumor. The radium was filtered through 2 mm. aluminum and five ply thickness of rubber dam, the radium source being about 4 mm. from the skin surface. Each square area received about 100 mg-hr. of radium in one hour, there being from thirty to fifty such squares distributed over the head. The results following this form of therapy were almost always poor.

In 1923 high voltage radiation replaced the radium. The rays were generated by a mechanical rectifier at a voltage of 200 kv. The filtration was 2 mm. Al plus 0.5 mm. Cu and a target-skin distance of 50 cm. Three 8 by 16 cm. portals were directed into the cerebrum, each of which received about 300 ma-min., an equivalent of approximately 1,000 r. The dose was repeated at two to three month intervals from three to five times. In 1928–1929 we started to irradiate the spine, about 1,000 r being delivered to the skin once or twice.

In 1932 the mechanical rectifier was replaced by a constant potential generator which operated at 165 kv. and 15 ma. This was a LeTour circuit, the ripple at 15 ma. being about 8 per cent. The cerebellar portals and spinal portals and the dose remained unchanged.

In 1936–1937 irradiation of the cerebrum was instituted, about 1,000 r being delivered to each side of the head in addition to the cerebellar portals.

In 1938 a second high voltage therapy unit was added to our department. Its rays are generated by a Villard type generator operating at 200 kv. and 20 ma. In order to duplicate the characteristics of the rays emitted by the pulsating Villard generator it was found necessary to operate the constant potential generator at 190 kv. and 14 ma. The half-value layer for both machines for an added filtration of 0.5 mm. Cu plus 1 mm. Al is 1.06 mm. Cu, the effective wave length being 0.145 Å, the output 45 r per minute. (It is noteworthy that no differences have been observed between the therapeutic effects of the constant potential and pulsating therapy machines.)

Present Technique. The present surgical treatment of medulloblastoma in the University Hospital is limited to a decompression of the patient by removal of the rim of the foramen magnum and atlas, and biopsy of the tumor. Grant[19] prefers this simple operative procedure to the more radical techniques because it relieves the increased

intracranial tension and verifies the nature of the growth without disseminating tumor cells throughout the subarachnoid space.

The head is irradiated, four to six weeks after operation, through five portals, three cerebellar and two cerebral (Fig. 4). The cerebral portals cover and are directed into each lateral hemisphere. Two suboccipital portals* are centered over each cerebellar lobe and are directed through the cerebellum into the vermis and fourth ventricle. The third cerebellar portal lies over the posterior one-third of the top of the head, directed caudad into the posterior fossa. The target-skin distance for all head and spinal areas is 50 cm. The therapeutic objective is to deliver approximately 2,000 r to each of the five skin areas.

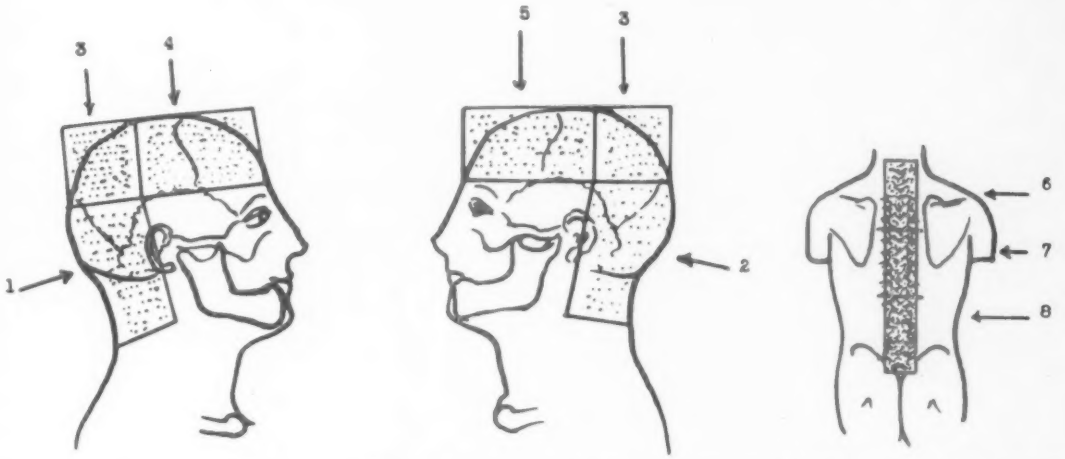

Fig. 4. Diagrammatic presentation of the portals employed in the treatment of cerebellar medulloblastoma. In the diagram, portals 1 and 2 seem to overlie the ear. Actually the ear is drawn forward in order to avoid irradiating it.

The spine is divided into two or three rectangular fields each wide enough to cover the lateral margins of the vertebral bodies. Each portal receives 2,000 roentgens.

The cerebellum is treated first. On the first day 50 r† is delivered to one suboccipital portal. The second day 75 r is delivered to the second suboccipital field and on the third day the third portal over the top of the head receives 100 r. If signs of increased intracranial pressure develop, the exposure is decreased to that which was tolerated the day previously. The dose is then increased, as tolerated, 50 r per day until the patient receives 200 r to one portal. Two cerebellar portals are then irradiated daily, the second starting with 50 r, increasing 50 r daily until it receives 100 r. Thus two cerebellar portals are treated alternately each day, one receiving 200 r, the second 100 r (Table 1). On the seventh day one spinal area is given 100 r in addition to the cerebellar irradiation. This exposure is increased 100 r daily until one spinal portal receives 300 r each day. On the eighth day treatment is started over one cerebral hemisphere.

The initial 50 r exposure to the cerebrum is increased 50 r daily until one cerebral portal receives 200 r in addition to the 300 r over the cerebellum and 300 r over the spine.

As a rule the technique outlined above (Table 1), assures delivery of from 3,700–4,000 r (including scatter) to the region of the fourth ventricle in patients with average-sized heads. In calculating the tumor dose in individual patients an attempt is always made to determine the exposure reaching a central point in the tumor rather than in the periphery.

As a rule, patients are irradiated twice

* Portal large enough to cover the entire area, usually 100 sq. cm.

† r in air without backscatter unless otherwise indicated.

each day rather than at one sitting. Unless this is done the daily exposure described above may not be tolerated. The entire course of treatment is usually completed in one month.

TABLE I

Days	Cerebellum			Cerebrum		Spine		
	Portal 1	Portal 2	Portal 3	Portal 4	Portal 5	Portal 6	Portal 7	Portal 8
1	50							
2		75						
3			100					
4	150							
5		200						
6		50	200					
7	200	100				100		
8	100		200	50			200	
9		200	100		100	300		300
10	200	100		150			300	
11	100		200		200			300
12		200	100	200		300		
13	200	100			200		300	
14	100		200	200				300
15		200	100		200	300		
16	200	100		200			300	
17	100		200		200			300
18		200	100	200		300		
19	200	100			200		300	
20	100		200	200				300
21		200	100		200	300		
22	200	100		200			300	
23	100		200		200			300
24		100		200		300		
25					200		300	
26				200		100		200
27					200			
28				200	100			
Totals	2000	2025	2000	2000	2000	2000	2000	2000

Outline of the daily doses employed in the treatment of cerebellar medulloblastoma. The table indicates twenty-eight treatment days. Patients are treated only six days in each week. The day of rest, Sunday, has not been indicated in the above outline. It must be remembered that some patients will not tolerate the daily doses indicated above. Such individuals are treated over a period longer than twenty-eight days.

Patients with brain tumors are routinely hospitalized for radiation therapy. This is a precaution which is especially desirable in patients with posterior fossa lesions in whom the threat of sudden ventricular block or cerebellar herniation constantly exists.[3,4] The chances for a sudden cerebral catastrophe are greatest during the first few days of irradiation. Headache, vomiting, visual disturbances, somnolence, and slowing of the pulse are manifestations of increased intracranial tension. Unless watched for constantly and the dose decreased when necessary, death may ensue. The danger becomes progressively less after the first ten days to two weeks following which the patient may leave the hospital and return daily for treatments. The menace of sudden increased intracranial pressure, however, is constantly present and must be guarded against.

Occasionally patients complain of irradiation sickness rather than increased intracranial tension. The usual methods for combating this illness are then instituted.

Blood counts are repeated once or twice each week throughout the radiotherapeutic course. Not infrequently anemia and leukopenia develop because of the extent of the bone marrow irradiated. The anemia may be controlled with drugs and transfusions when necessary. Leukopenia is a more difficult problem. *Radiation therapy is usually stopped when the total white count reaches 2,000 to 2,500.* It is interrupted sooner if the reticulocytes and platelets drop below normal.

In our experience reticulocyte and platelet counts are of inestimable value in patients with leukopenia due to irradiation. We do not hesitate to continue radiotherapy in the face of a leukopenia providing repeated reticulocyte and platelet counts remain normal. We do, however, reduce the daily exposure to the spine and cerebrum. The number of patients who develop leukopenia due to irradiation are limited. We therefore hesitate to recommend the above criteria for continued irradiation unconditionally. Many more individuals with leukopenia must be watched before the reliability of reticulocyte and platelet counts may be established.

Epilation invariably follows this therapeutic course. The hair over the cerebrum usually returns. The cerebellar area frequently remains permanently bald.

Four to six months later the entire radiotherapeutic course is repeated. No further irradiation is advised unless clinical evidence of recurrence develops.

RESULTS

An analysis of end-results in a disease as relatively uncommon and fatal as cerebellar medulloblastoma is extremely difficult. The question arises as to when a case may be regarded as fully recovered. Should a patient be considered cured after a period of three or five years? Should a patient with residual stigmata of the destructive effects of the growth be considered "well"? Or should one depend upon the postoperative duration of life to determine end-results?

In reviewing the literature we were impressed with the manner in which Cutler, Sosman and Vaughan[8] presented their end-results in the radiation treatment of cerebellar medulloblastomata. These authors divided their cases into eight groups as follows:

Group I Postoperative or case fatalities.
Group II. Dead without operation or irradiation.
Group III. Operation followed by no irradiation.
Group IV. Operation followed by inadequate irradiation.
Group V. Operation followed by irradiation of cerebellar area only.
Group VI. Operation followed by irradiation of cerebellar area and spine.
Group VII. Operation followed by irradiation of cerebellar area, spine and ventricular system.
Group VIII. Treatment by irradiation only.

We decided to divide our cases similarly, as far as possible, for three reasons. First, because it seemed to present best the clinical improvement, in terms of the prolongation of life, attending the various operative and radiotherapeutic techniques. Second, because it might help to standardize the manner in which end-results should be expressed, in this disease, in the future. Third, because it seemed to be a method which would permit the pooling of comparable cases treated by others, thereby increasing the total number and enhancing their statistical value (Table II).

The records of 56 patients with histologically verified cerebellar medulloblastoma, operated upon by Dr. Charles H. Frazier and Dr. Francis C. Grant, were available for this analysis. Of this group 31 had received some form of radiation therapy (Table II).

TABLE II

AVERAGE POSTOPERATIVE DURATION OF LIFE IN MONTHS

	Number of Cases	Present Series	Cutler, Sosman and Vaughan[8]	Number of Cases
Group I	20	0	0	20
Group II	0	0	0	3
Group III	5	2.0	5.6	14
Group IV	12	9.3	15.9	16
Group V	9	24.5	17.0	5
Group VI	8	28.4	18.7	9
Group VII	2	24.5	28.2	12
Group VIII	0	0	16.5	2

Group I. Postoperative fatalities. There were 11 postoperative deaths, a mortality of about 19 per cent.

Group II. Death without operation or irradiation. There were no patients in this group.

Group III. Operation followed by no irradiation. There were 14 patients in this group who lived an average of 3.1 months postoperatively. The shortest duration of life was one month, the longest six months.

Group IV. Operation followed by inadequate irradiation. One finds it difficult to define "adequate" and "inadequate" irradiation. In fact we do not recommend the use of these terms. As an example of this Frazier, Alpers, Pendergrass and Chamberlin[17] considered a tumor dose of 2,000 r to be "adequate" treatment. A tabulation of the present series of patients, according to tumor dose and end-results, indicates that 3,000 r is safe in many instances and the results seem to be better. We have therefore

included in Group IV only those cases in which the tumor dose was less than 3,000 r. There were 12 patients in this group who lived an average of 9.3 months after operation. The shortest duration of life was two months, the longest twenty-four months.

Group V. Operation followed by irradiation of the cerebellar area only, tumor dose being 3,000 r or higher. There were 9 patients who received tumor doses of at least 3,000 r. Their average duration of life after operation was 24.5 months. The shortest duration of life was five months, the longest forty-seven months. None in this group are alive at present.

Group VI. Operation followed by irradiation of the cerebellar area and spine, tumor dose to the cerebellar area being 3,000 r or higher. There were 8 patients in this group who lived an average of 28.4 months postoperatively. The shortest duration of life was fifteen months. Three patients are still alive in this group, living fifteen months, seventeen months and forty months respectively.

Group VII. Operation followed by irradiation of the cerebellar area, spine and ventricular system, the tumor dose to the cerebellar area being 3,000 r or higher. There were two patients in this group. One is still alive nineteen months postoperative. The second lived thirty months after operation.

Group VIII. Treatment by irradiation only. We have not treated any cerebellar medulloblastomata in this manner.

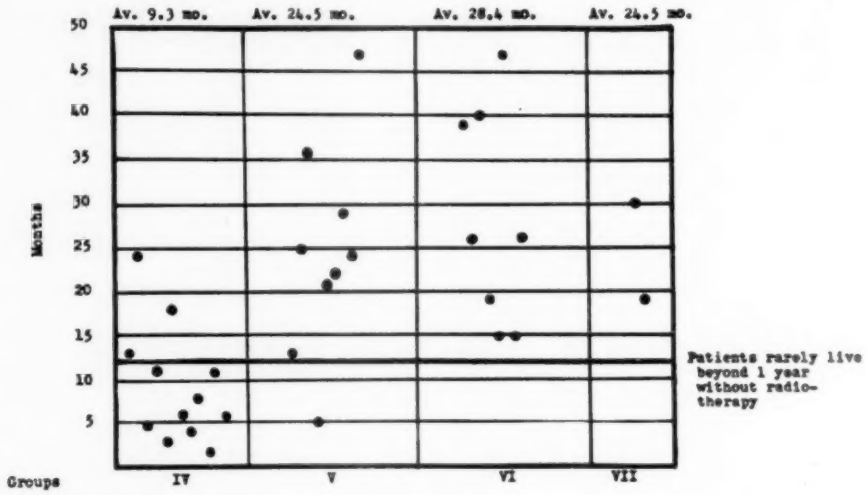

FIG. 5. Diagrammatic presentation of the distribution of the postoperative survival periods of the patients with cerebellar medulloblastoma included in this series. The cases have been separated into different groups in the manner described in the text. Group IV includes the patients whose primary tumor dose was less than 3,000 r. The patients included in Groups V, VI and VII received primary tumor doses of more than 3,000 r. The distribution of the postoperative survival periods in Groups V, VI and VII indicates an improvement in the postoperative results which is highly significant.

The postoperative survival period of the patients included in Groups IV, V, VI and VII are presented in diagrammatic fashion in Figure 5. There appears to be a highly significant difference between the mean survival period of the patients in Group IV who received a primary tumor dose of less than 3,000 r compared with the patients in Groups V, VI and VII, each of whom received a primary tumor dose of more than 3,000 r.

HISTOPATHOLOGIC EFFECTS OF IRRADIATION

Frazier and Alpers,[16] reporting their neuropathologic observations in 23 cases of medulloblastoma, studied before and after

radiotherapy, reported definite changes in 19 cases, and little or none in 4 of those revealing definite irradiation effects, 5 were mild, 4 moderate, and 4 marked.

According to Frazier and Alpers[16] and others,[1,10,11,23,31,32] the most striking changes were seen in the tumor cells. The cells were pyknotic, stained poorly, and frequently presented vacuolated nuclei. In addition, an actual reduction in the cellularity of the tumor, 35 per cent, could be demonstrated by checking cell counts before and after irradiation.

The vascular response was less striking. Definite endothelial changes, varying in degree, were observed but complete vascular occlusion was only noted occasionally.

The connective tissue elements in the tumor also demonstrated striking changes. The fibrous tissue, collagen, and reticular components were definitely more prominent after roentgen therapy. Brody and German suggested that the post-irradiation fibrous transformation in these tumors might render them more amenable to surgical extirpation. In addition, attention has been called to the fact that tumors examined after radiotherapy revealed more cellular necrosis than unirradiated tumors. The significance of this observation has not been determined.

In general, no definite correlation seems to exist between the intensity of irradiation and the tumor response. Frazier, Alpers, Pendergrass and Chamberlin,[17] however, believe that a parallelism between tumor dose and histological effect could be demonstrated provided the interval between irradiation and microscopic examination was not too long. Marked tumor response has been observed in a tumor given 1,200 r, whereas minimal histopathologic changes were seen in a tumor receiving about 5,200 r. This is in accord with the observations of Frazier and Alpers,[16] and others, who have stated that only a minority (20–25 per cent) of the medulloblastoma cells appear to respond to irradiation. Whether this is due to inadequate irradiation or a predominance of cell growth over cell death is undecided. We believe, however, that some of the above opinions may be modified if more attention is paid to the time interval between irradiation and the microscopic examination.

In studying the effect of irradiation upon the peripheral and deep portions of treated medulloblastomata it was found that the histopathological changes were invariably more pronounced in the periphery of the tumor.

COMMENT

Before the advent of radiotherapy the average postoperative duration of life in patients with medulloblastoma varied from six to twelve months. Recently, however, with the adoption of radiation therapy, these figures have improved considerably, approaching a two to three year survival period in selected, thoroughly treated series. In our own experience these patients have lived an average of about twenty-eight months following operations. Four patients are still alive, fifteen, nineteen, thirty and forty months.

From these data one is forced to conclude that whereas postoperative irradiation has succeeded in prolonging life, it has not succeeded in effecting cures. Several five year survival records are in the literature,[21,34] but these are admittedly rarities. The question arises, what can be done to improve our results in the treatment of medulloblastoma?

Everyone agrees that early diagnosis is essential. Unfortunately, the location and nature of these growths are such that early diagnosis is extremely difficult. By the time the signs and symptoms of increased intracranial pressure and nerve degeneration manifest themselves the tumor has already become sizable, and complete surgical removal, without dissemination of the growth, almost impossible. The primary treatment of cerebellar medulloblastoma becomes, therefore, a radiotherapeutic problem. After obtaining the maximum effect

from irradiation, should a second operation be planned? Possibly trying to cure medulloblastoma is a *triumph of hope over reason.* At any rate, the results at present leave much to be desired.

We believe that these tumors should not, as a rule, be irradiated until after they have been identified histologically, and the increased intracranial tension relieved surgically. After a lapse of four to six weeks high voltage radiation or comparable radium therapy should be directed into the cerebellum and an effort made to build up as large a tumor dose as is possible using a fractionated technique. Coincidentally the cerebrum and spine must be treated to prevent or minimize the chances for metastases. Although 2,000 r delivered to three cerebellar, two cerebral, and two or three spinal areas has been recommended, it may be that the solution to the problem lies in using larger doses provided no permanent injury is done the patient. Our present plan is to repeat the entire therapeutic course in four to six months. At the completion of the second series no further treatment is employed. The patients are checked neurologically for evidence of recurrence every two to three months. They are warned to return sooner if symptoms simulating their original complaints develop. The importance of reporting zonal or localized pain or paresthesia is impressed upon the patient. In our experience these symptoms develop as the earliest manifestations of spinal cord extension.

Irradiation of the proper segment of the cord is almost always followed by complete relief of symptoms. In spite of the segmental destitution of symptoms the entire cord is irradiated, each area being given 2,000 r. Although the symptoms often disappear following the application of 1,000 to 1,400 r to the skin surface, the treatment is continued until the 2,000 r has been delivered. The cord symptoms failed to respond in one patient. At postmortem it was evident that, even though the tumor masses had responded, the resultant gliosis in the vicinity of the spinal nerve was marked enough to produce symptoms.

SUMMARY

1. The radiation therapy used in the treatment of cerebellar medulloblastoma has been reviewed.

2. Our technique at present is to irradiate the entire cerebrospinal axis and cerebellum.

3. The evidence suggests that 3,000 r (primary tumor dose) can be delivered safely to the cerebellar lesion.

4. The postoperative duration of life has increased with advances in radiotherapeutic techniques and procedures. The results thus far leave much to be desired.

REFERENCES

1. Bailey, P. Further notes on cerebellar medulloblastomas, effect of roentgen radiation. *Am. J. Path.*, 1930, *6*, 125–136.
2. Bailey, P., and Cushing, H. Medulloblastoma cerebelli, a common type of midcerebellar glioma of childhood. *Arch. Neurol. & Psychiat.*, 1925, *14*, 192–224.
3. Béclère, A. Radiotherapy in tumors of cerebrospinal cavity. *Am. J. Phys. Therapy*, 1927, *3*, 539–545.
4. Béclère, A. Radiotherapy of brain tumors. *Am. J. Phys. Therapy*, 1929, *6*, 57–63.
5. Brody, B. S., and German, W. J. Medulloblastoma of the cerebellum; report of 15 cases. *Yale J. Biol. & Med.*, 1933, *6*, 19–29.
6. Cairns, H., and Russell, D. S. Intracranial and spinal metastases in gliomas of brain. *Brain*, 1931, *54*, 377–420.
7. Cushing, H. Experiences with the cerebellar medulloblastomas; critical review. *Acta path. et microbiol. Scandinav.*, 1930, *7*, 1–86.
8. Cutler, E. C., Sosman, M. C., and Vaughan, W. M. Place of radiation in treatment of cerebellar medulloblastomata. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 429–453.
9. Davis, L., and Cutler, M. Experimental and clinical study of use of radium in brain. *Surg., Gynec. & Obst.*, 1933, *56*, 280–293.
10. Davis, L., and Weil, A. Effect of radiation therapy upon intracranial gliomata. *Ann. Surg.*, 1937, *106*, 599–618.
11. Deery, E. M. Remarks on effects of roentgen therapy upon gliomas. *Bull. Neurol. Inst. New York*, 1936, *4*, 572–587.
12. D'Errico, A. Diagnosis and treatment of medulloblastomas of brain. *Texas State J. Med.*, 1939, *35*, 475–478.
13. Dyke, C. G. Roentgen ray treatment of tumors of brain and skull. *Bull. New York Acad. Med.*, 1935, *11*, 392–402.

14. Elsberg, C. A., Davidoff, L. M., and Dyke, C. G. Roentgen treatment of tumors of brain in operating room by direct radiation through open wound. *Bull. Neurol. Inst. New York*, 1937, *6*, 19–32.
15. Elvidge, A., Penfield, W., and Cone, W. Gliomas of central nervous system. *Ass. Research Nerv. & Ment. Dis., Proc. (1935)*, 1937, *16*, 107–181.
16. Frazier, C. H., and Alpers, B. J. Effect of irradiation on gliomas. *Ass. Research Nerv. & Ment. Dis., Proc. (1935)*, 1937, *16*, 68–106.
17. Frazier, C. H., Alpers, B. J., Pendergrass, E. P., and Chamberlin, G. W. Effect of irradiation on gliomas. Am. J. Roentgenol. & Rad. Therapy, 1937, *38*, 203–237.
18. Grant, F. C. Clinical study of midline cerebellar tumors in children. *S. Clin. North America*, 1929, *9*, 1155–1168.
19. Grant, F. C. Personal communication.
20. Gross, S. W. Tumors of brain in infancy; clinical and pathologic study. *Am. J. Dis. Child.*, 1934, *48*, 739–763.
21. Knight, G. Subtentorial tumours. *Post-Grad. M. J.*, 1939, *15*, 195–209.
22. Nelson, A. A. Metastases of intracranial tumors. *Am. J. Cancer*, 1936, *28*, 1–12.
23. Olivecrona, H., and Lysholm, E. Notes on roentgen therapy of gliomas of brain. *Acta radiol.*, 1926, *7*, 259–267.
24. Pancoast, H. K. Treatment of brain tumors by radiation. Am. J. Roentgenol., 1922, *9*, 42–47.
25. Pancoast, H. K. Experience in the treatment of brain tumors by irradiation during the past thirteen years. Am. J. Roentgenol. & Rad. Therapy, 1928, *19*, 1–15.
26. Pancoast, H. K., and Grant, F. C. Experience in irradiation treatment of cerebellar tumors. *Ass. Research Nerv. & Ment. Dis.*, December meeting, 1926, p. 610.
27. Pendergrass, E. P., Hayman, J. M., Houser, K. M., and Rambo, V. C. Effect of radium on normal tissues of brain and spinal cord of dogs, and its therapeutic application. Am. J. Roentgenol., 1922, *9*, 553–569.
28. Pendergrass, E. P., and Wilbur, D. L. Tumors of brain with widespread metastases; report of 2 cases. *Arch. Neurol. & Psychiat.*, 1928, *19*, 437–445.
29. Rand, C. W., and Van Wagenen, R. J. Brain tumors in childhood; review of 38 cases. *J. Pediat.*, 1935, *6*, 322–339.
30. Sachs, E., Rubinstein, J. E., and Arneson, A. N. Results of roentgen treatment of series of 119 gliomas. *Arch. Neurol. & Psychiat.*, 1936, *35*, 597–616.
31. Tarlov, I. M. Effect of roentgenotherapy on gliomas. *Arch. Neurol. & Psychiat.*, 1937, *38*, 513–536.
32. Towne, E. B. Roentgen-ray treatment of tumors of brain. *J. Am. M. Ass.*, 1925, *84*, 1813–1815.
33. Tracy, F. E., and Mandeville, F. B. Roentgen therapy of medulloblastoma cerebelli. *Radiology*, 1931, *17*, 259–264.
34. Wigser, A. M. Inoperable gliomas of brain of six years duration treated with deep x-ray therapy. *J. Med.*, 1933, *13*, 591–592.
35. Winkelman, N. W., and Eckel, J. L. Midline cerebellar tumors ("medulloblastoma"). *Surg., Gynec. & Obst.*, 1937, *63*, 372–381.

DISCUSSION

Dr. M. C. Sosman, Boston. The main theme in this paper presented by Dr. Pendergrass and his co-workers is one that we will all agree with in the face of the facts presented, i.e., that there has been an increased prolongation of life in these patients as the total amount of irradiation given has increased. As a corollary to this the results have also been better as more extensive irradiation has been given to the entire brain and spinal cord.

As none of the patients with cerebellar medulloblastoma survived more than one year after surgical treatment alone, as the operative mortality is 25 per cent even in the best of hands, as biopsy or attempted removal of the tumor undoubtedly increases the chances of metastatic spread of the tumor through the cerebrospinal fluid pathways, and finally as this tumor is by far the most radiosensitive of all brain tumors, Dr. Cutler and I took the next logical step in therapy and advocated irradiation alone without surgery.

I shall not repeat the detailed discussion as to the difficulties of diagnosis and the inherent dangers in such a method as they are available in our paper read before this Society at Atlantic City in 1935.* I would, however, like to emphasize three things, two of which we said at that time: (1) All of the 81 cases reported by us are dead at the present time with 2 exceptions, one patient out of the 79 who were operated on and verified is still alive but economically useless now thirteen years after operation, probably the most heavily irradiated patient in the series, and one patient of the 3 who were treated by irradiation alone without operation is alive, well, and working as a graduate nurse nine years after her first treatment. (2) We said then and repeat now that irradiation without de-

* Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 429–453.

compression is not contraindicated in selected cases of medulloblastoma suspects, providing there is close cooperation between the neurological surgeon and the radiologist. (3) The third point is that these tumors respond so promptly and so well to irradiation that we can tell in ten days by the marked improvement in the patient's condition whether our diagnosis is correct or not. Certainly none of you would hesitate to treat a large mediastinal mass without a biopsy, and if there were a prompt regression of the mass and a marked relief of symptoms, you would all logically conclude that you were dealing with a malignant lymphoma. Therapeutically speaking, the cerebellar medulloblastomata are the lymphomata of the intracranial tumors. And it is not necessary to treat the entire cerebrospinal system before deciding whether the tumor is a medulloblastoma or one better treated by surgery. In ten days, with treatments only to the cerebellar area, you can be fairly certain as to your diagnosis, and then if the characteristic lymphoma-like response is obtained, the rest of the cerebrospinal axis can be thoroughly irradiated.

In conclusion, I am sure that some of these patients can be saved with the more thorough, more extensive, and more prolonged irradiation which Pendergrass, Hodes and Godfrey advocate, and I would like to compliment them on their careful, logical and accurate presentation, although they seem to be still too conservative.

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LOW BACK PAIN RESULTING FROM ARTHRITIS AND SUBLUXATIONS OF THE APOPHYSEAL JOINTS AND FRACTURES OF THE ARTICULAR FACETS OF THE LUMBAR SPINE*†

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THE term, *low back pain*, should not be considered a diagnosis, but should be used as the description of a symptom. It is no more a diagnosis than is the word *headache*. In either instance the etiologic factors producing the symptoms of low back pain or headache must be found and through them the diagnosis be established. Low back pain can arise from many causes, and no one, two or a dozen conditions account for all the pains in this area. This discussion is limited to a group of patients suffering from low back pain as the result of: (1) arthritic changes in the lumbar intervertebral apophyseal joints, (2) subluxations of these joints, and (3) fractures of the articular facets.

In the routine study of patients with low back pain we strongly recommend that they be roentgenographed in the anteroposterior, lateral, and right and left posterior oblique positions. The consulting physician is encouraged to order such a "lumbar back series" made on four 10 by 12 inch films instead of the usual anteroposterior and lateral views taken on two 14 by 17 inch films. The importance and interpretation of the oblique views are not as fully understood as are the anteroposterior and lateral views. For this reason, plus the fact that most of the lesions to be described are shown best in the oblique views, a thorough discussion of this position is warranted. Hubeny[7] in 1931 was the first in this country to demonstrate that the oblique position was necessary for an adequate examination of the articular facets and joints. Ghormley and Kirklin[3] in 1934 published an excellent article calling attention to the advantage of the oblique views for studying these structures. They brought out the fact that many cases of low back pain are the result of actual injury to these joints and should be explained on this basis rather than on the basis of a ligamentous strain or injury. Hubeny and these authors both mentioned that arthritic changes in these joints can give rise to back pain. Hadley[4] in 1935 reported several cases of subluxation of the apophyseal joints and ably discussed the etiology and mechanism which brought them about. He also listed the ways in which subluxations may cause back pain. Two years later Morton[8] wrote on the value of the oblique views for demonstrating the defects of the facets, apophyseal joints, and posterior neural arch. He reported a case with fracture of the pars interarticularis and introduced the S-shaped line as a test for apophyseal subluxations. Oppenheimer[10] in 1938 published an excellent summary of the disease and disorders that involve these joints. He made a detailed analysis of the arthritides.

TECHNIQUE

The anteroposterior and lateral films are made in the usual manner. The lateral view should be true with both lateral borders of the vertebrae overlying each other and the central beam passing through the fifth lumbar vertebra. A translucent pad of cotton several inches thick should be placed

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† The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.
‡ At present Lieutenant Commander, Medical Department, United States Naval Reserve, on active duty.

under the patient's side between the crest of the ilium and the widest part of the chest. The purpose of the pad is to prevent any sagging of the lumbar spine, especially in individuals of the asthenic and hyposthenic habitus with wide hips and narrow chests.

The films made in the oblique position are taken by placing the patient on the roentgenographic table in the supine position with the legs extended and then raising one side of the body off the table to about a 35° angle (Fig. 1). Considerable leeway is permitted in the selection of the angles, usually somewhere between 30° and 45°, since there is wide variation in the obliquity of the facets among individuals and even between different vertebrae of the same individual. It is wise for the technician to take one oblique film and develop it immediately while the patient remains in the same position. A quick look at the wet film will determine whether or not the patient is in the proper position or if further adjustment is necessary. The film in the opposite oblique position is then made at the same angle. Occasionally several films must be taken with the patient at different angles to bring about adequate visualization of the various joints. It is hardly necessary to state that the patients must be carefully supported by sand bags and immobilized by a tight binder. A roentgen tube with a small focal spot and the Potter-Bucky grid should always be used.

Fig. 1. The oblique position. The angle most commonly used is one about 35°, although it is frequently necessary to increase it to as much as 45°, depending on the obliquity of the articular facets. The patient must be firmly supported by sand bags and immobilized by a tight compression band.

Anatomy

The films made in the oblique positions demonstrate the articular facets and apophyseal joints to the best advantage. Certain points in the roentgen anatomy of these and related structures can be reviewed by examining an oblique film made on a so-called "normal subject" (Fig. 2). The bodies of the vertebrae are easily recognized, in this instance the fourth and fifth lumbar and the first sacral. The transverse processes are shown on each side. The inferior articulating facets are posterior and stand out in clear relief. Immediately opposite them and anterior are the superior articular facets of the next lower vertebra. The area between the facets is the apophys-

eal joint space. The inferior and superior facets, together with the surrounding soft tissues, are called an apophyseal joint. The facets are made of dense, hard, articular bone, as contrasted with the relatively soft, cancellous bone of the vertebral bodies. The joint surfaces of the facets are covered with hyaline or articular cartilage. The joint is lined with a synovial membrane. It is surrounded by a joint capsule and contains the facets will reduce the size of the foramen sometimes sufficiently to cause pressure or irritation on the nerve roots, resulting in sciatic pain. Ghormley and Kirklin[3] believe that after certain injuries there may be sufficient swelling or effusion into the joint or its surrounding structures to encroach on the foramen enough to cause definite irritation of the adjacent nerve roots with resultant sciatic pain.

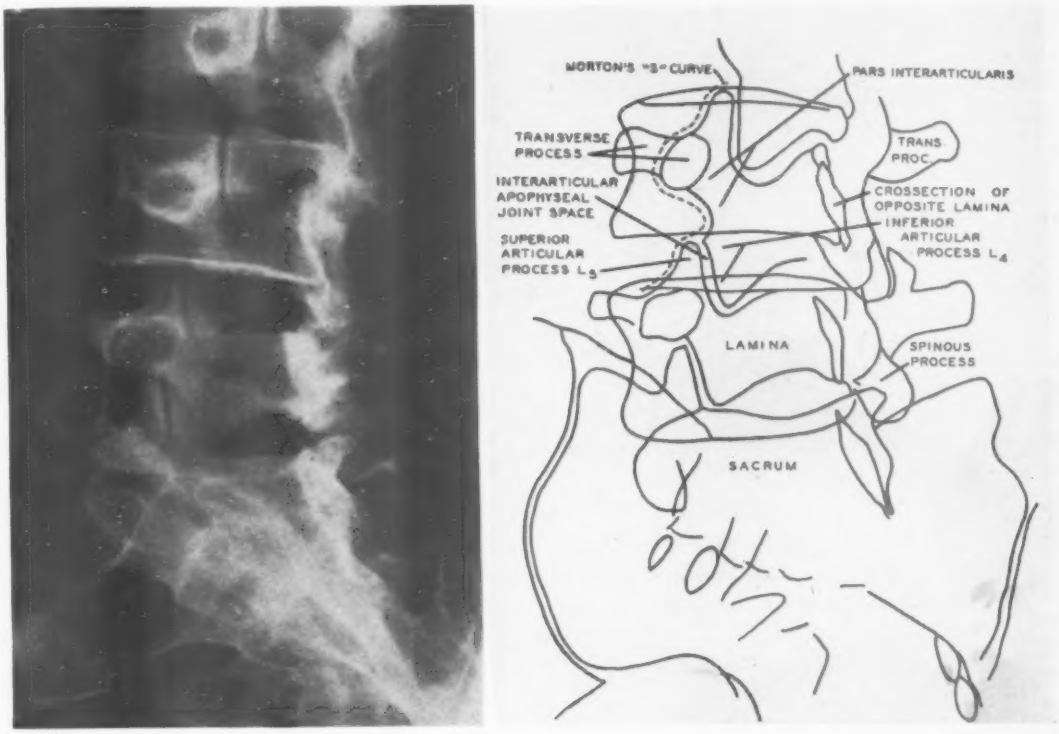

Fig. 2. A roentgenogram made in the oblique position on a "normal" individual. The important structures are identified on the tracing. Note that each apophyseal joint lies slightly farther anteriorly from above downward. The dotted line represents the so-called normal S-curve which extends between two adjacent apophyseal joints.

joint fluid. The apophyseal joints are true diarthrodial joints quite similar in their construction to the elbow or knee joint and are subject to the same types of disorders and diseases.

The inferior and superior facets of adjacent vertebrae form the posterior border of the intervertebral foramen through which the nerves entering and leaving the spinal cord pass. This is an important anatomical relationship, since a subluxation of

The superior and inferior facets of the same vertebra are connected by the thinnest portion of the neural arch which Chandler[2] called the interarticular isthmus, but which is more commonly known as the pars interarticularis (Fig. 2 and 3). It is that portion of the posterior neural arch where the lamina and the inferior articular facets join the heavy bases of the pedicle, transverse process and superior articular facet. The pars interarticularis is thus a

strategic connecting point in the neural arch, and for that reason is subjected to great stresses and strains. After violent injuries this area should be carefully inspected for fractures that must always be differentiated from congenital clefts, as the pars interarticularis is also the most frequent site for their occurrence.

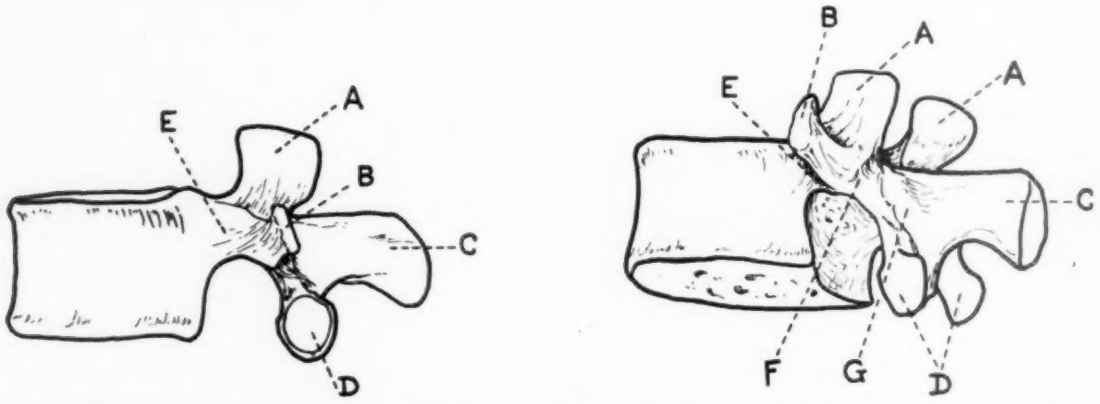

Fig. 3. Diagrammatic tracings of the third lumbar vertebra to demonstrate the necessity of taking an oblique view to visualize the pars interarticularis, and to separate the articular facets. *Left:* Lateral view of third lumbar vertebra. *Right:* Oblique view of third lumbar vertebra. *A*, superior articular facet; *B*, transverse process; *C*, spinous process; *D*, inferior articular process; *E*, pedicle; *F*, pars interarticularis; *G*, lamina.

The oblique position provides a view of the entire lamina, which extends between the pars interarticularis and the spinous process. The lamina of the opposite side is seen in cross section.

NORMAL VARIATIONS OF THE FACETS AND APOPHYSEAL JOINTS

Before discussing abnormal changes of the apophyseal joints and articular facets, it is necessary to realize that they exhibit a marked degree of variation from individual to individual and even from vertebra to vertebra in the same individual. The roentgenologist must be familiar with these variations in order to make a correct interpretation of the film and to understand the anatomical limitations afforded by the oblique projection. In our experience the temptation has been "to read" too much from such films rather than not enough.

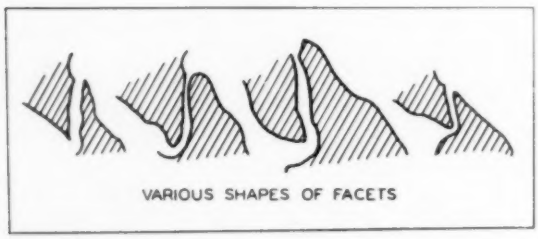

Fig. 4. Diagrammatic tracings of several facets of different lumbar vertebrae to show the marked variation in size and shape of these structures.

The normal variations of the facets and apophyseal joints include:

(1) Variations in size and shape.
(2) Variations in the degree of obliquity of the articular surfaces.
(3) Variations in the width of the joint spaces.
(4) Variations in the vertical alignment of the facets
  (a) due to inherent structural form
  (b) due to changes in body position.

Figure 4 is a series of tracings which demonstrate the wide range in the size and shape of the facets. Only the extremes are of possible clinical significance. Mueller[9] mentions that there may be even a congenital absence of the facets.

Variations in the degree of obliquity of the articular surfaces of the facets are common even in the same patient. The apophyseal joints between the second and third lumbar vertebrae and between the fourth and fifth are clearly shown; yet the joint between the third and fourth lumbar vertebrae appears obliterated because of the dif-

ferent angle of the articular surface of these facets from the sagittal plane of the vertebra (Fig. 6). In addition, Horwitz and Smith[6] found from a study of cadavers that the articular surface of the superior facets of the lumbar vertebrae is concave, and in certain instances sufficiently curved so that anomalies "are common, that they give improper support to the body structures and are deficient in their weight bearing and strain resisting properties." Haggart[5] considers those individuals with rudimentary and asymmetrical lumbosacral facets with the articular surfaces facing superior-

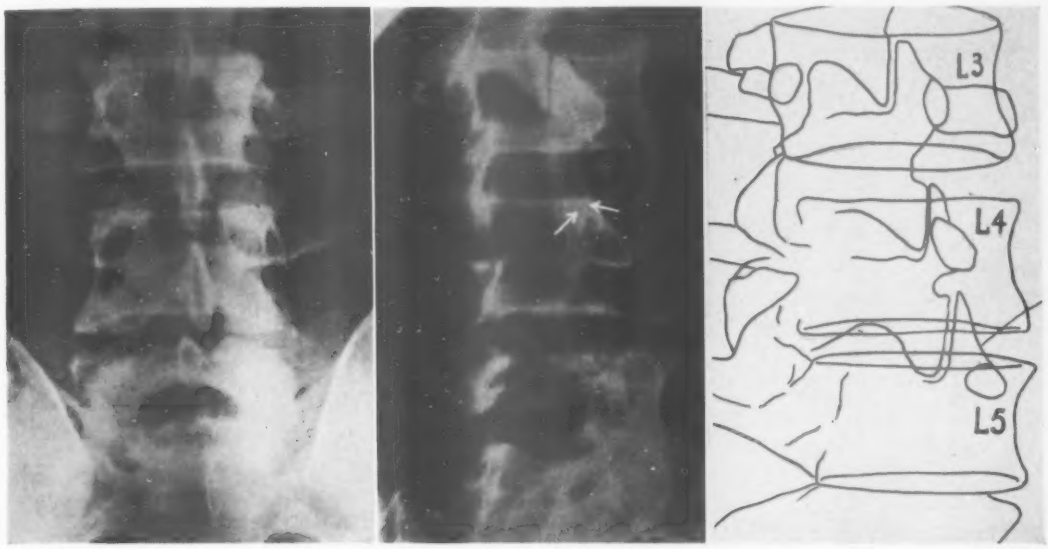

Fig. 5. The apparent obliteration of the apophyseal joint space between the third and fourth lumbar vertebrae is the result of a normal variation in the obliquity of the articular surface of these facets. A sufficient curvature of the articular surface of the inferior articular facet would also cause an apparent obliteration of the apophyseal joint. This type of variation must not be confused with the ankylosing or suppurating types of arthritis. This variation must be recognized as one of the limiting factors in the value of the oblique position in the interpretation of arthritic changes in these joints.

it is impossible for the roentgen rays to pass through the joint space. On the film the joint space would then appear to be narrowed or even obliterated by the superimposed shadows of the curved facet and thus lead to an erroneous interpretation. Taylor[11] recently demonstrated that the direction in which the facets face is an important factor in maintaining the stability of the lumbar spine, particularly the lumbosacral joint. For example, when the articular surfaces parallel the anteroposterior plane, it is possible for the vertebrae, under the proper circumstances, to slip forward. When the articular surfaces are in the transverse plane, it is possible for the vertebrae to slip sidewise, but not forward. Taylor believes that variations of these interiorly as possessing unstable lumbosacral joints. He further advocates surgical fusion of such articulations if a trial of adequate conservative therapy has not been successful.

Variations in width of the normal joint space are slight since the spaces are narrow, usually perpendicular, and of uniform width. Marked narrowing or obliteration of a single joint or pair of joints is usually the result of anomalies, as explained above, and one is hardly justified in making a diagnosis of an ankylosing type of arthritis in such instances (Fig. 5) Horwitz and Smith[6] first called attention to this limitation in the use of the oblique projection.

Variations in the vertical alignment of the facets due to inherent structural form

are common. Usually the articular surfaces of the facets stand directly opposite each other to form what Morton[8] calls the S-curve (Fig. 2). Frequently there is an apparent overriding of their articular surfaces (Fig. 8). This unequal position of the facets by itself should not be called an apophyseal subluxation. All roentgenologists have seen these unequal alignments in patients who have never had a back pain, and they should not be considered pathologic but simply as a normal variation.

Variations in the vertical alignment of the facets due to changes in body position occur commonly and are often of considerable extent. In order to obtain some idea as to the normal range of movement of the facets, we made films on a series of individuals placed in extreme scoliosis, hyperflexion and hyperextension (Fig. 6). In extreme scoliosis the alignment of the articular surfaces is definitely altered. On the side of the greater curvature the facets are pulled away from each other. On the side of the lesser curvature the facets are pushed together with a slight overriding of their articular surfaces. In marked hyperextension there is a considerable shift in the vertical alignment of the articular surfaces of the facets. In addition, the joint space becomes wedge-shaped. In hyperflexion the joint spaces are narrowed. The vertical alignment of the articular surfaces is only slightly altered. In all of these positions the changes in the positions of the facets and joints are greatest at the point of the greatest spinal curvature. A few months ago we had the opportunity of making a roentgeno-

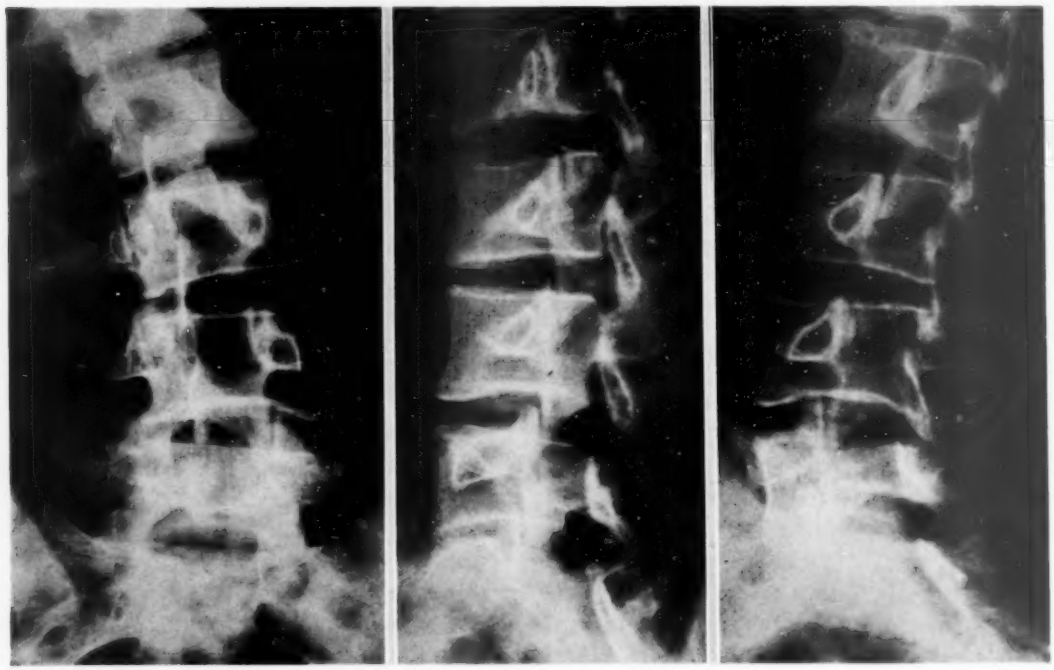

Fig. 6. Illustrates the average range of motion in the lumbar apophyseal joints of a young adult in the positions of scoliosis, extreme hyperflexion and hyperextension. *Left:* Extreme scoliosis. On the side of the greatest curvature the articular facets are shifted apart, while on the right side they overlap. *Center:* Hyperflexion. The shift in position of the articular facets in these different positions gives some idea of the great amount of almost continuous movement to which these joints are subjected in ordinary living. The articular surfaces of the facets are shifted in the vertical axis several millimeters. The intervertebral discs are widened posteriorly and compressed anteriorly. *Right:* Hyperextension. The articular surfaces of the facets are still shifted in the vertical axis. The joint space is now wedge-shaped, being widest superiorly and narrowest inferiorly. The intervertebral foramina are smaller, and the intervertebral discs are widest anteriorly and thinnest posteriorly.

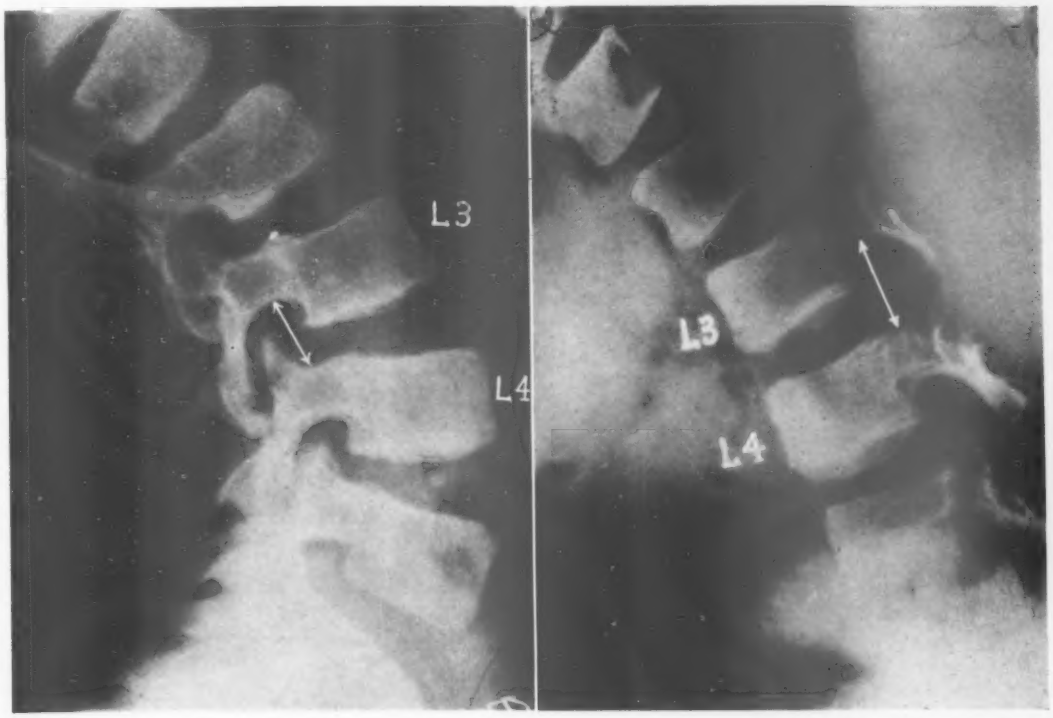

FIG. 7. Demonstrates the extreme range of motion that is present in the apophyseal joints of a contortionist. This young girl is twelve years of age and has already achieved wide acclaim for her feats. In performing the forward and backward bending maneuvers there is no actual anatomical dislocation, but the great range in the spread of the opposing articular surfaces of the facets enables her to assume these extraordinary positions. *Left:* Extreme backward bending. Note the exaggerated closure of the intervertebral foramen and the marked widening of the intervertebral discs anteriorly. *Right:* Extreme forward bending. Note the great enlargement and "opening" of the intervertebral foramen. The intervertebral discs are now widened posteriorly and compressed anteriorly.

graphic examination of a contortionist in various positions. The performer was a young girl twelve years of age whose agent stated that she excelled in both forward and backward movements of the spine—an achievement which he claims is found rarely in the same individual. In Figure 7 are the roentgenograms of this girl in the extreme forward and backward positions. The films probably demonstrate the maximum shift in the position of the articular surfaces of the opposing facets. The range of motion between the two positions as measured between the third and fourth lumbar vertebrae is 7 mm. Note the great enlargement of the intervertebral foramen in hyperflexion as compared to that in hyperextension. The intervertebral discs are widened by hyperextension and become wedge-shaped. It is the abnormal freedom of movement, and not a dislocation, which makes it possible for her to assume these fantastic positions.

ARTHRITIS OF THE APOPHYSEAL JOINTS

In elderly people hypertrophic irregularities about the articular margins of the facets frequently can be demonstrated and at times may be of clinical significance (Fig. 8). The presence of such hypertrophic spurs in themselves is of no more significance than are the spurs present about the margins of the bodies of the vertebrae. However, since there is considerable range of motion in these joints, it seems possible that violent flexion or extension of the spine at the time of an injury may cause sufficient overriding of these articular margins

to draw the sharp, bony projection across the articular cartilage of the opposing facet, causing hemorrhage, edema, and swelling of the joint with resultant pain. As explained by Ghormley and Kirklin, such swelling may be sufficient to cause pressure on the nerves passing through the intervertebral foramen and in this way produce sciatic pain. It seems reasonable to assume that such a sequence of events can occur and may explain the cause of many cases of low back pain in elderly people who have had a recent fall or accident and on whom the roentgenograms are reported as negative. The hypertrophic irregularities should not be referred to as arthritis since they probably represent senile changes occurring in the bone.

The most common type of arthritis that can be demonstrated in the apophyseal joints is the so-called rhizomelic spondylitis of the Marie-Strümpell type. In the oblique position the articular facets can be distinguished, but the joint space between them is obliterated. The opposing facets give the appearance of being glued together (Fig. 9). These changes involve all of the apophyseal joints and to about the same degree and extent.

Since the apophyseal joints are true diarthrodial joints, they should be subject to the same types of arthritis as the knee, elbow, or wrist joint. However, the roentgen diagnosis of a localized, suppurative arthritis involving one or two of the apophyseal joints is quite difficult to make because the variations in the obliquity of the facets, as explained above, may give the appearance of an ankylosed or destroyed joint space.[6] The roentgen diagnosis of suppurative arthritis can only be suspected from the films and can be established only when the

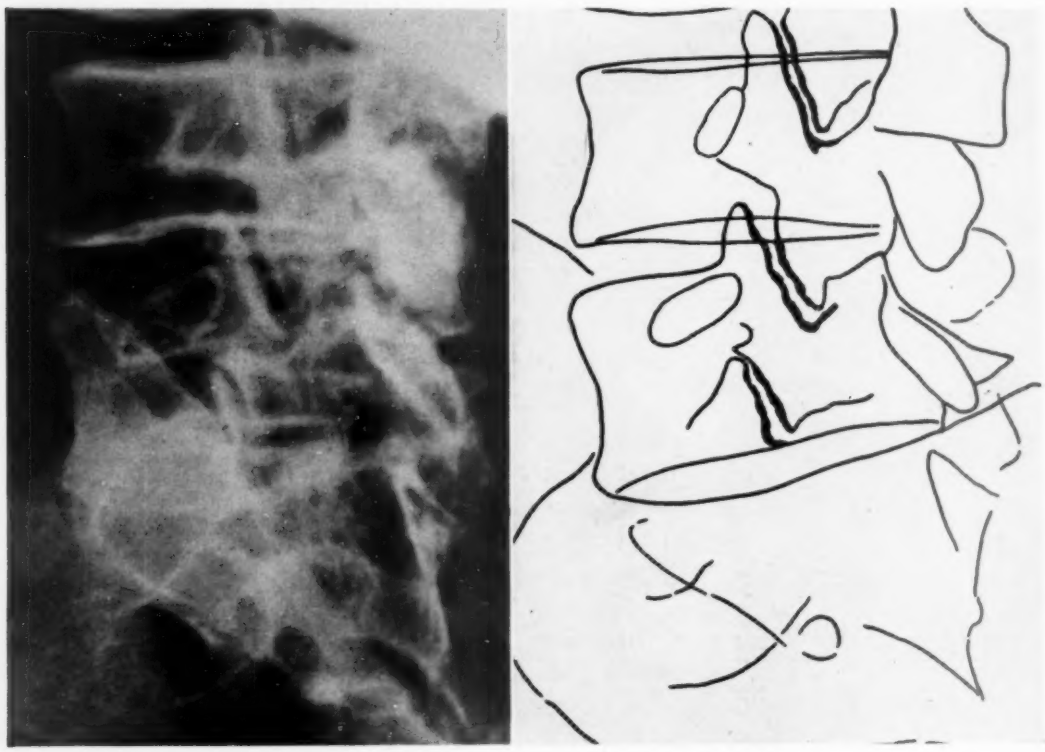

Fig. 8. Hypertrophic irregularities about the articular margins of the facets. This is a frequent occurrence in elderly people. These irregularities may be responsible for certain cases of back pain in injuries that cause extreme hyperflexion or extension. The overriding of the facets may damage the articular cartilage and joint capsule, causing hemorrhage, edema, and swelling of the joint with resultant pain.

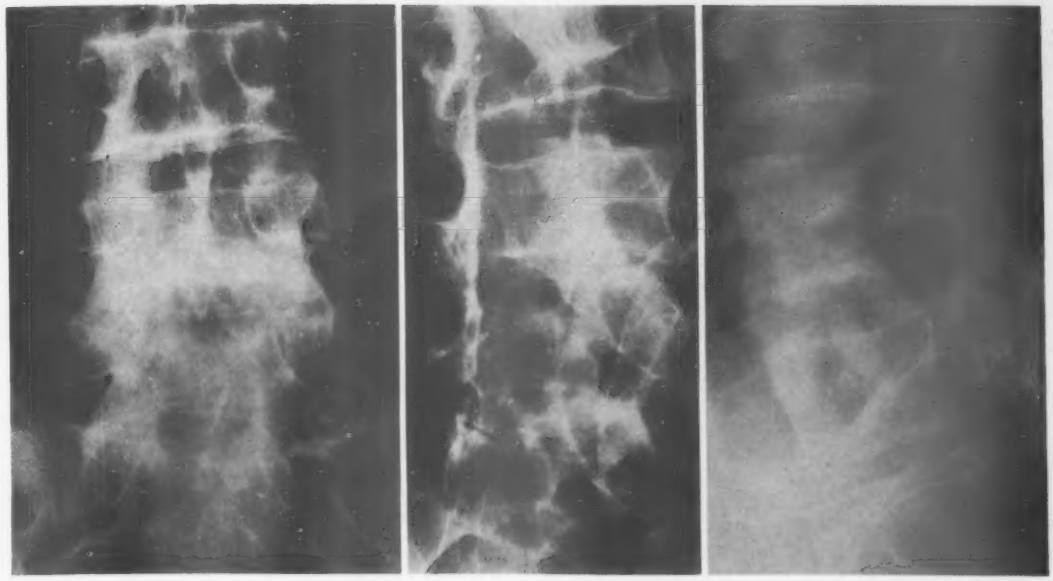

Fig. 9. In rhizomelic spondylitis of the Marie-Strümpell type, the apophyseal joints become ankylosed. All of the bones become demineralized. The joint space is obliterated, and the white cortical margin of the facets disappears. There is practically an uninterrupted transition from the vertebral bodies to the articular facets, and thence across to the opposing facets. All of the apophyseal joints are usually involved and to about the same extent. The disease usually begins in the sacroiliac and hip joints, which become fused very early. These patients exhibit a real immobile "poker spine." (Barnes Hospital No. 80961) Patient was aged twenty-six, married, white, shoe cutter. Stiffness and pain began in hip joints seven years ago and then gradually involved the spine. The right hip is ankylosed. White blood count 14,950. Pathological gallbladder is the only known source of infection.

clinical history and physical findings substantiate this suspicion (Fig. 10). In this series there was only one patient on whom we made this rare diagnosis. The patient was a young married service station operator, aged twenty-six, who had severe localized pain directly over the apophyseal joint between the fourth and fifth lumbar vertebrae on the left side. This pain was of six weeks' duration. During this period he had a low grade fever and a mild leukocytosis. All of the examinations and the other findings were essentially negative. The films of the lower lumbar spine revealed a marked narrowing of the apophyseal joint space between the fourth and fifth lumbar vertebrae on the left. The opposing articular facets were hazy and poorly defined. They exhibited some increase in density, and bony sclerosis. The appearance resembled more a subsiding suppurative type of arthritis than any other type of joint disease. While the diagnosis could not be proved, it is reasonable to assume that it was correct.

SUBLUXATIONS OF THE APOPHYSEAL JOINTS

Subluxations of the apophyseal joints are not common, but occur sufficiently often to warrant greater attention than is customarily given them. In this clinic such a diagnosis was made thirty-one times in the past year. The purpose of emphasizing the normal variations in the shapes of the articular facets and the normal range of motion in the apophyseal joints was to establish the fact that the shape of the facets or overriding of the opposing articular surfaces does not establish the diagnosis of an apophyseal subluxation (Fig. 11). Such alterations are within the normal range of variations both anatomically and physiologically for these structures. In our opinion,

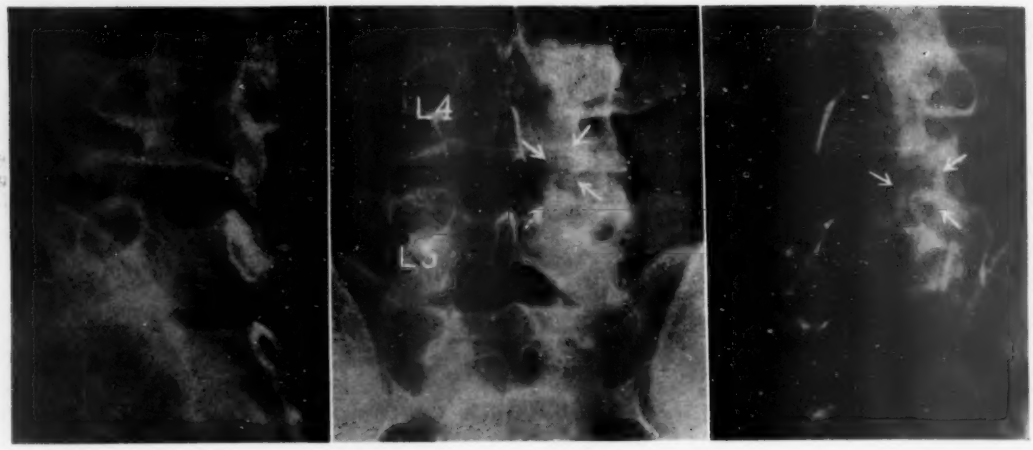

Fig. 10. A suppurative type of arthritis of an apophyseal joint is an unusual occurrence. In this instance a destructive process is limited to the apophyseal joint between the fourth and fifth lumbar vertebrae on the left, and it is the suspected site of a subsiding suppurative arthritis. The joint space is very narrow, the outline of the articular facets is irregular and fuzzy, and they show a moderate sclerosis. The clinical history and findings were in accord with such a diagnosis. (Barnes Hospital No. 77682) The patient was a white male, married, aged twenty-six, service station operator. Complained of low back pain for six weeks localized to the region between the fourth and fifth lumbar vertebrae on the left. Temperature 99–100° F., white blood count 9,500. No recognized focus of infection other than roentgenologic findings in films of the back.

Fig. 11. The apparent overriding of the articular facets forming the apophyseal joint between the fourth and fifth lumbar vertebrae is a normal variation and should not be interpreted as an apophyseal subluxation, since there is no impingement of the facets on the adjacent vertebrae, and the intervertebral disc is of normal width.

the roentgen diagnosis of an apophyseal subluxation can be made only in the presence of a narrowed intervertebral disc and an impingement with erosion of the ends of the facets on the lamina and pedicle of the adjacent vertebra. A narrowed intervertebral disc from any cause forces the adjacent vertebrae closer together and this, in turn, causes the facets to slide past each other and their articular surfaces to override. If the intervertebral disc is sufficiently thinned, the tip of the superior facet of the lower vertebra will impinge on the pedicle of the upper vertebra, and the tip of the inferior facet of the upper vertebra on the lamina of the lower vertebra. The pedicle, lamina and facets are covered with periosteum, and they do not constitute adequate weight-bearing surfaces. The pressure and movement of the facets against these structures eventually produce erosion or sclerosis and, in most instances, both. This destructive action is painful and should certainly be considered as one of the causes of low back pain. Hadley[4] lists this disarrangement as one of the three ways in which apophyseal subluxations may cause

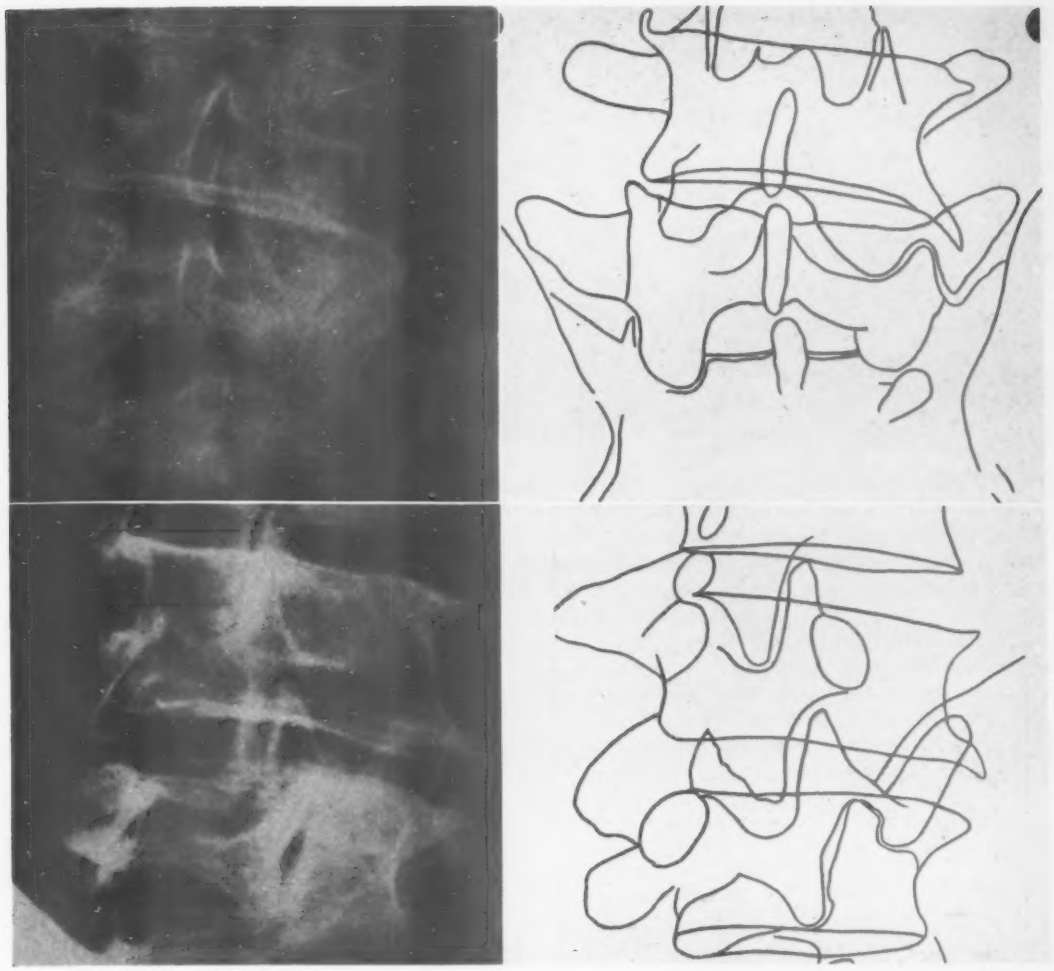

FIG. 12. Case 1. Apophyseal subluxation. The narrowing and destruction of the intervertebral disc between the fifth lumbar vertebra and the first sacral vertebra has forced the pedicle of the fifth lumbar vertebra to rest on the superior articular facet of the first sacral vertebra. The bearing of weight on these structures has caused a marked erosion and sclerosis of the facet and pedicle, as is shown especially well in the oblique position. Note the marked overriding of the articular surfaces of the inferior articular facet of the fifth lumbar vertebra and the superior articular facet of the first sacral vertebra. This amounts to practically 1 cm. These findings are our idea of what should be diagnosed as an apophyseal subluxation that can account for low back pain. In these cases spinal myelography should also be done if the patient is having pain along the course of the sciatic nerve. (Washington University Clinics No. E 24592) The patient was a farmer, aged forty-seven, married, who complained of low lumbar back pain of one year's duration—no sciatic radiation. Treated for one year by orthopedic manipulations and supports without permanent relief of pain, of which he still complains to this date.

pain. The other two are: (1) by causing tension upon the capsular ligaments, and (2) by encroachment of the facets on the lumen of the intervertebral foramen. The exact amount of alteration required to produce pain by these last two methods has never been ascertained, and therefore there are no criteria for the roentgen diagnosis of these two conditions. Thus the detection of erosion or sclerosis at the site of impingement is required to establish the diagnosis of an apophyseal subluxation. If the diagnosis of apophyseal subluxation is to account for back pain, the presence of a complicating posterior protrusion of the intervertebral disc must be ruled out in these

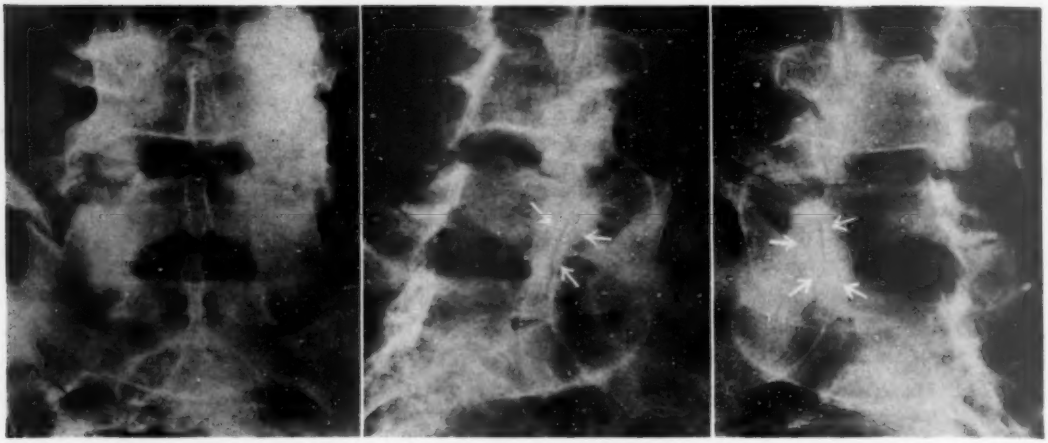

Fig. 13. Case II. Apophyseal subluxation. The intervertebral disc between the first lumbar vertebra and the first sacral vertebra is narrowed and is the basis for the development of a subluxation of the apophyseal joints. Note the impingement of the superior articular facets of the sacrum on the pedicle of the fifth lumbar vertebra, and the inferior articular facets of the fifth lumbar vertebra on the lamina of the sacrum. There is marked eburnation and sclerosis of these structures as well as a narrowing of the apophyseal joints due to destruction of the articular cartilages. This degree of apophyseal subluxation is mild to moderate in extent and conservative methods of treatment are indicated. The inferior articular facet of the fourth lumbar vertebra on the left is very irregular and was probably fractured when he fell on some stairs seven years ago. (Washington University Clinics No. C 68070) The patient was a male, Negro, aged fifty-four, who complained of low back pain for several months. The pain was not characteristic of a sacroiliac lesion, but simulated it. The pain was not of a sciatic distribution. Orthopedic manipulations and a firm support have relieved his symptoms a great deal.

cases. The following cases are examples of what we consider to be significant apophyseal subluxations.

Case I (Fig. 12). For several years this farmer, aged forty-seven, has had persistent pain in the left lumbosacral area. The disc between the fourth and fifth lumbar vertebrae and that between the fifth lumbar vertebra and the sacrum on the left side are narrowed. The superior articular facet of the first sacral vertebra is flattened and eroded as the result of impingement against the pedicle of the fifth lumbar vertebra, which is also thinned and eroded. These structures do not withstand weight bearing without these changes. Both of them show considerable sclerosis and eburnation. In estimating the degree of erosion of the pedicle of the fifth lumbar vertebra, it is necessary to remember that it is normally the narrowest of all the lumbar vertebrae. The articular surfaces of the superior facet of the first sacral vertebra and the inferior facet of the fifth lumber vertebra have slipped past each other for a distance of 1 cm. The narrowed intervertebral disc, the eroded pedicle and facet, and the overriding of the articular surfaces of the superior and inferior facets constitute the diagnosis of an apophyseal subluxation which is of value and accounts for this patient's low back pain. In this case there is a marked closure of the intervertebral foramen, but it is not sufficient to cause compression of the nerve roots since he did not have pain along the course of the sciatic nerve. This case illustrates the most advanced type of an apophyseal subluxation and the type in which a facetectomy and spinal fusion is usually necessary to provide relief of symptoms.

Case II (Fig. 13). The roentgenogram of this patient, a Negro, male, aged fifty-four, shows that the intervertebral disc between the fifth lumbar vertebra and the first sacral vertebra is narrowed sufficiently to allow the superior facets of the sacrum to impinge on the pedicle of the fifth lumbar vertebra and the inferior facets of this vertebra to ride on the lamina of the sacrum. At the point of contact and weight bearing the bone is dense and eburnated, and the surfaces are ground by erosion. The articular surfaces of the facets in these apophyseal joints are subluxated. The apophyseal joint space is narrow, indicating a destruction of the articular cartilage. This is the most common type of

apophyseal subluxation and may be seen in various stages of development. Facetectomy with spinal fusion is the method of treatment and should be done if the patient's pain is sufficient to warrant this operation.

Case III (Fig. 14). This case is used to illustrate the fact that even a very marked narrowing of an intervertebral disc does not necessarily result in an apophyseal subluxation. This patient was a housewife, aged thirty-one, who had suffered from lumbar back pain for over ten years. During that time she had been admitted to the hospital on repeated occasions for examinations and treatment without obtaining permanent relief. For the past two years she has had pain down her right leg. Her last roentgenograms are reproduced in Figure 14. The intervertebral disc between the fourth and fifth lumber vertebrae is extremely narrow. The oblique films fail to reveal any erosion or sclerosis of the pedicle and inferior articular facets of the fourth lumbar vertebra or of the lamina and superior articular facets of the fifth lumbar vertebra. The articular surfaces of these facets are in direct apposition, and there is no evidence of apophyseal subluxation. With the introduction of spinal myelography this patient was selected as an ideal candidate because of her persistent low back pain which was unrelieved by any orthopedic procedures. A large, unilateral, intraspinal protrusion of the fourth intervertebral disc was found on the right side. The protruded disc was removed, with complete disappearance of her symptoms. In this connection I wish to state that whenever we can demonstrate an apophyseal subluxation present at the same level as an intraspinal protruded disc, we call this finding to the attention of the neurological surgeon. The apophyseal subluxation, as we define it, indicates that the facets are performing weight-bearing duties. In such cases, if the surgeon simply removes the intraspinal portion of the protruded disc, the patient is very likely to have residual pain at this site. Therefore it is recommended that in

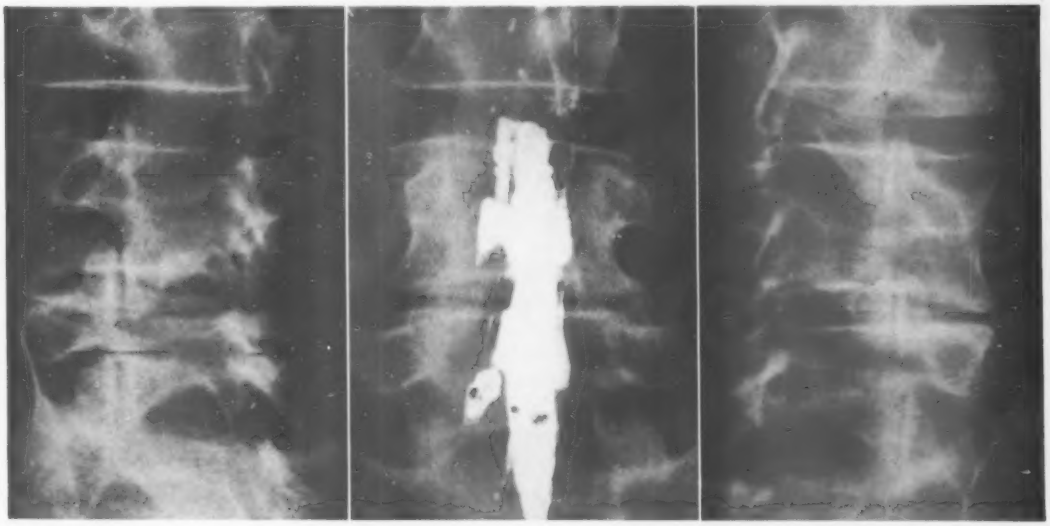

Fig. 14. Case III. Narrowed intervertebral disc without associated apophyseal subluxations. The intervertebral disc between the fourth and fifth lumbar vertebrae is decreased in the vertical dimension by at least 60 per cent, yet in the oblique positions the opposing facets of the fourth apophyseal joints are in direct apposition. The pedicle of the fourth lumbar vertebra, the lamina of the fifth lumbar vertebra, and the facets forming the joint have not undergone erosion or sclerosis. There is no evidence of apophyseal subluxation. Spinal myelography revealed a large, unilateral intraspinal protrusion of the fourth intervertebral disc on the right. Surgical removal of the protruded disc afforded the patient complete relief. In this type of case a facetectomy should not be done at the time of the laminectomy for the removal of the disc. Facetectomy should be done only when an apophyseal subluxation accompanies an intraspinal protrusion of the disc and there is evidence of weight bearing on the facets. (Barnes Hospital No. 35790) The patient was a housewife, aged thirty-one, who had a long history of lumbosacral back pain extending over a period of ten years. She had repeated orthopedic manipulations and procedures for relief of pain without success until the protruded disc was found and removed at operation.

the examinations of patients for intraspinal protruded discs the apophyseal joints also be carefully checked for evidence of weight bearing and if found, a facetectomy is also indicated at the time the protruded disc is removed.

FRACTURES OF THE ARTICULAR FACETS

Fractures of the articular facets are not as common (about one-eighth as common) as compression fractures of the lumbar vertebrae. Fractures of the facets usually result from a direct violent blow to the back. Some authors believe that severe twisting of the lumbar spine may result in fractures of the articular facets. Some fractures that have been seen in this clinic resulted from a heavy weight falling across the lumbar spine producing a sudden hyperextension of the back. The roentgen diagnosis of fractures of the lumbar articular facets is complicated by the frequent occurrence of two important congenital anomalies. The first one is the presence of persistent centers of ossification that occur usually below the tips of the inferior articular processes of the lumbar vertebrae. As a rule, they are bilateral. The fissures between the facets and the accessory ossicles are smooth and sharply demarcated by a white cortical line (Fig. 15). These criteria[1] distinguish them from fractures whose borders are usually ragged and irregular. The oblique view often displays the accessory ossicles to better advantage.

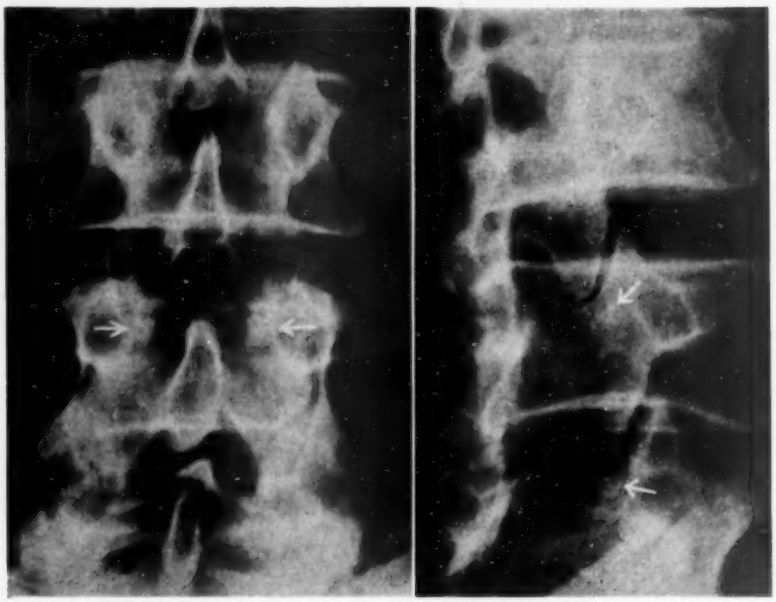

Fig. 15. Persistent epiphyses of the inferior articular facets must always be distinguished from fractures of the articular facets. The persistent accessory ossicles usually occur below the tips of the inferior facets. They are usually bilateral and the fissures between the facets and ossicles are smooth and sharply demarcated. The oblique view generally affords greater detail and clarity in the visualization of these structures. (Barnes Hospital No. 39946) This patient was a male, aged forty-five, unemployed, who had a history of being in an accident several years ago. At that time he received a fracture of the right tibia and fibula. He has since had partial diability of the right lower extremity.

The second congenital anomaly that must be distinguished from fractures is the congenital cleft in the lamina of the vertebrae. This condition is called spondyloschisis (Fig. 16). These clefts occur most frequently at the point of union of the lamina with the pars interarticularis. According to Willis[12] they occur in 5 per cent of all individuals and are the precursors of practically all cases of spondylolisthesis.

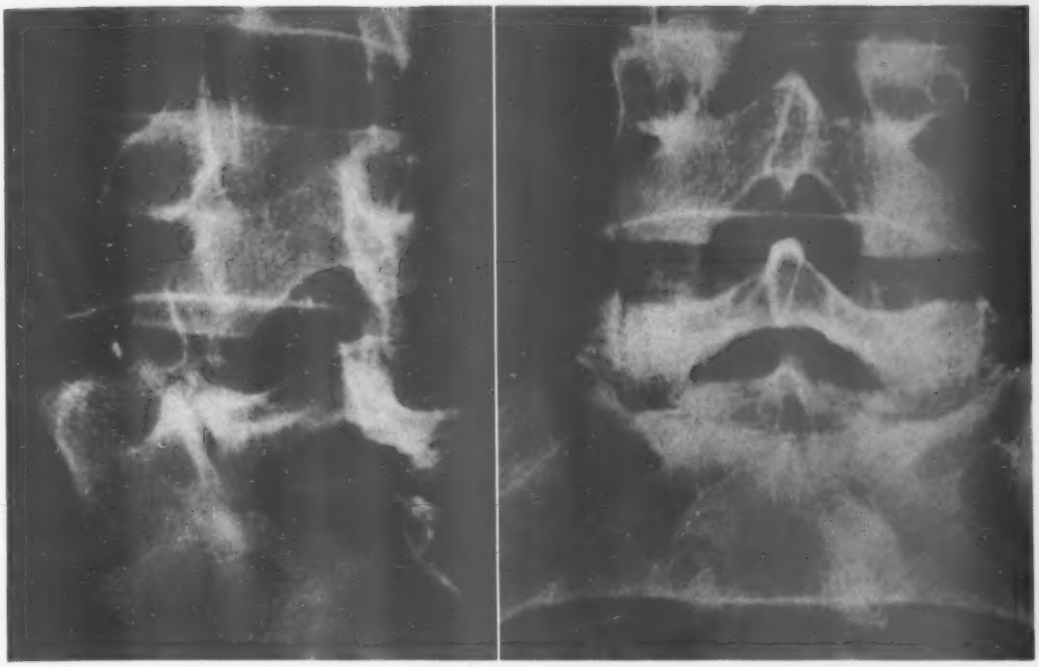

Fig. 16. Fractures of the articular facets must be distinguished from congenital clefts which frequently occur at the base of the lamina and the pars interarticularis. The clefts are usually bilateral, but in this instance the cleft is present only on the right side. The oblique view shows that the cleft occurs at the pars interarticularis of the fifth lumbar vertebra. The base of the superior articular facet of the fifth lumbar vertebra is separated from the inferior articular facet and lamina of this vertebra. The margins of these structures are smooth and rounded. They are devoid of any signs of new bone formation or regeneration. (Barnes Hospital No. 81833) This patient, a railroad brakeman, aged thirty-nine, was injured a year prior to admission when a freight engine turned over, and he was pinned in the cab. At the railroad hospital his back was taped and his foot kept in hot packs for several days. He was back on his feet in five or six days, but the pain in his back persisted. There was no limitation of motion. The patient was treated with a fracture board and orthopedic manipulation with some relief of pain.

The margins of the clefts are smooth, clear-cut and free from evidence of callus. They are usually bilateral. The oblique views often demonstrate the details and sites of these congenital clefts with far greater clarity than can be obtained from just the anteroposterior and lateral views.

The following cases are characteristic examples of fractures of the articular facets.

Case iv (Fig. 17). This patient, a male, aged sixty, received a sudden, violent injury to his lower back at the level of the third lumbar vertebra. He was an ambulatory private patient, and his record is not complete. The injury occurred several months before these films were made. Films made previous to this time had been negative, but the man's pain had persisted. For this reason the roentgenograms shown in Figure 17 were made. The inferior articular facet of the third lumbar vertebra on the left side has a dark, irregular, jagged line running transversely across the tip of this facet. The line is jagged and irregular as compared with the smooth, rounded line seen at the accessory ossicles that are shown in Figure 15. The fracture line could be suspected in the anteroposterior view, but it can be readily identified in the oblique position.

Case v (Fig. 18). This graduate nurse complained of lumbosacral back pain for many years. She dates the onset of her pain to the time when she was lying on the floor on her abdomen and another nurse playfully sat down on the small of her back. Immediately she experienced a severe pain and felt "something crack" in her spine. Pain and tenderness have persisted over a small area of her back at

Fig. 17. Case IV. Fracture of the inferior articular facet of the third lumbar vertebra. The fracture line is irregular and ragged. The fracture is unilateral and involves only one facet. Compare with Figure 15.

the level of the lumbosacral joint and to the right of the midline. Repeated orthopedic measures have been unsuccessful. Spinal myelography failed to reveal an intraspinal protrusion of an intervertebral disc. A review of her old roentgenograms showed nothing except that oblique views had never been made. We then tilted her head down to remove the lipiodol from the lumbar subarachnoid space and made the film shown in Figure 18. A dark, jagged fracture line is at once recognized running across the base of the right inferior articular facet of the fifth lumbar vertebra. There is also an oblique fracture through the superior articu-

Fig. 18. Case V. Oblique fractures of the opposing articular facets. The fractures remained undiagnosed for a period of five years. The fractured inferior articular facet of the fifth lumbar vertebra on the right side has been displaced forward. Careful examination will show the oblique fracture line running through the superior articular facet of the first sacral vertebra. It is important that the anteroposterior and lateral views gave no suggestion of this fracture. The oblique view is especially valuable in the recognition of such fractures.

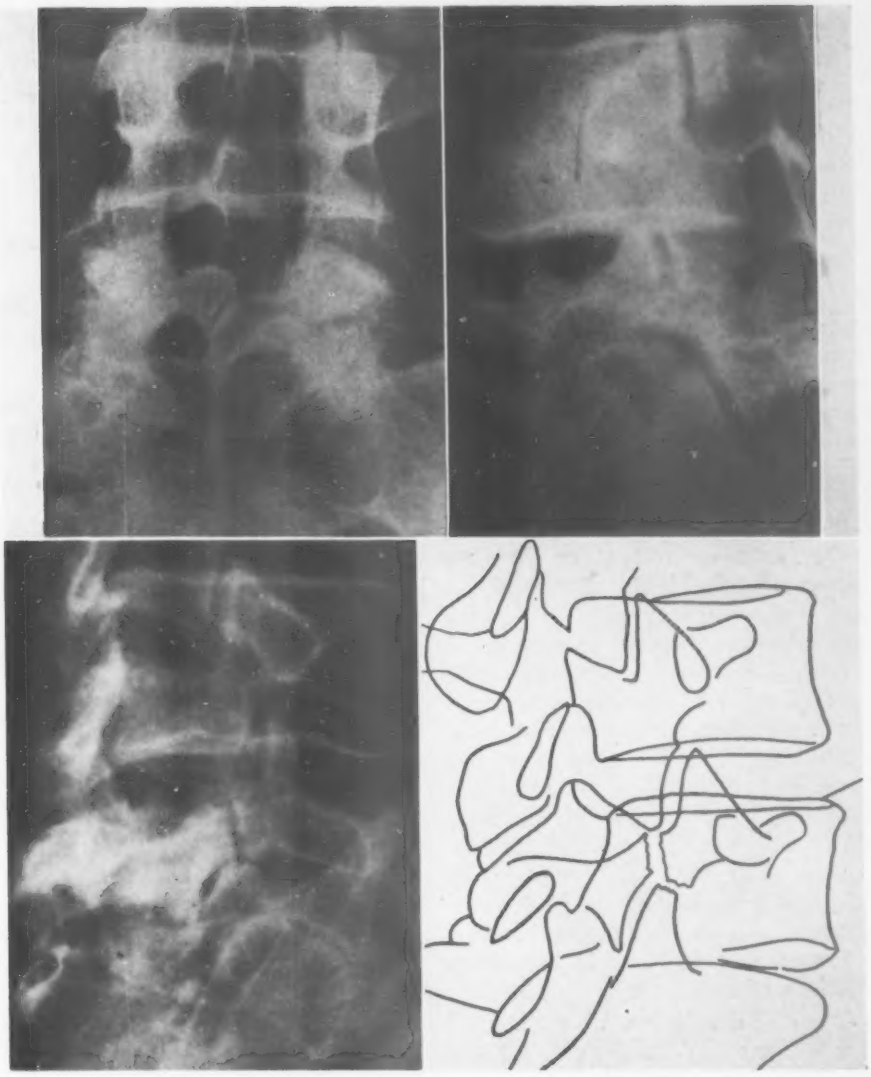

Fig. 19. Case VI. Fracture of the pars interarticularis of the fifth lumbar vertebra, right. Fractures of the pars interarticularis are rare, and great care has to be used in distinguishing them from the congenital clefts that occur at the site, as is demonstrated in Figure 16. The edges of the fracture are quite ragged. There is a definite history of trauma to this area with persistent, localized tenderness. On the original films a faint, dark line could be seen crossing the base of the lamina of this vertebra on the left side. It could not be positively identified as a fracture and could not be reproduced on these prints. This case was another instance in which the fracture was demonstrated only in the oblique positions. (Barnes Hospital No. 73406) Three years before entering the hospital this farmer, aged thirty-eight, was unloading sacks of feed from a hayrack, when the floor broke and the patient fell through with one leg. Compression fractures of the fourth and fifth lumbar vertebrae and sacroiliacs were reported as being present after injury by his local physician. A body cast was applied and worn for five months. All pain was relieved except that over the sacroiliacs. Three years after the initial injury a lumbosacral fusion was done with considerable relief of pain, but a definite amount of pain and limitation persisted. With the demonstration of fractured facets, as shown above, the orthopedic surgeon did a fusion of the fourth and fifth lumbar facets and of the fifth lumbar and first sacral vertebrae. This procedure has given the patient considerable relief and enabled him to return to work.

lar facet of the fifth lumbar vertebra. The fragments are in good position, and no gross evidence of bone regeneration was present. Both of these fractures were obscured in the

routine lateral and anteroposterior views and had remained undiagnosed for a period of five years. This patient has taught us a valuable lesson, for now we rarely subject a patient to spinal myelography without taking oblique films of the suspected area before injecting the lipiodol. A lumbosacral fusion was done with moderate relief of her symptoms.

Case vi (Fig. 19). Two years ago this workman, aged thirty-eight, fell from a scaffold and injured his back. For some time he has been incapacitated by a persistent, severe, low lumbar back pain. The anteroposterior and lateral roentgenograms show that the vertebrae are in good alignment, and that there is no narrowing of the intervertebral discs. On palpation there was definite tenderness over the region of the lamina of the fifth lumbar vertebra on the right side. The anteroposterior and lateral films revealed only a small spina bifida occulta of the lamina of the fifth lumbar vertebra at its junction with the spinous process. The orthopedic surgeon ordered the oblique views because of the pain and tenderness to the right of the midline. The film made in the right oblique position shows a large fracture line extending across the pars interarticularis. The edges of the fracture line are rough and irregular. The inferior surfaces of the fragments rest on the superior articular facet of the first sacral vertebra. The tip of this facet has been flattened by erosion resulting from weight bearing. The orthopedic surgeon performed a lumbosacral fusion which has relieved the patient's pain so that he has been able to return to his work.

SUMMARY AND CONCLUSIONS

1. "Low back pain" is a term that should be used to describe a symptom and should not be used as a diagnosis.

2. The posterior oblique positions are necessary for a complete study of patients with low back pain as they are the only means of obtaining an adequate study of the articular facets and apophyseal joints. It is recommended that the oblique views be included in the routine roentgenograms that are made on patients with low back pain.

3. The articular facets and apophyseal joints normally exhibit a marked degree of variation in size and shape; in the degree of concavity of their articular surfaces; and in the alignment, width, shape, and range of motion of the joints. The vertebral alignment of opposing facets can be considerably altered by changes in body position.

4. Variations in the obliquity of the articular surfaces of the facets and in the degree of concavity are very common and limit the value of the oblique position for use in the diagnosis of localized ankylosing types of arthritis that are limited to one or two apophyseal joints.

5. The apophyseal joints are true diarthrodial joints and are therefore subject to the same types of diseases as other diarthrodial joints.

6. The roentgenologic diagnosis of apophyseal subluxation as a cause of low back pain should be based on the following criteria:

(a) A narrowed intervertebral disc.
(b) Impingement with erosion and sclerosis of the inferior articular facet on the lamina of the next lower vertebra with impingement of the superior articular facet of the lower vertebra on the pedicle of the vertebra immediately above.
(c) An overriding of the articular surfaces of the opposing vertebrae.

The sequence is usually a narrowing intervertebral disc, then a subluxation of the apophyseal joints and finally an impingement of the facets with resulting erosion of the pars interarticularis.

7. Apophyseal subluxations may vary in degree and in the extent of the erosion that is produced on the pedicle and lamina of the adjacent vertebra. The greater the degree of erosion, the greater the pain and disability, is the usual rule.

8. Extensive erosion of these structures is evidence of considerable weight bearing, and a facetectomy or a fusion should be considered if the pain is sufficient to warrant this procedure.

9. From our experience we recommend the taking of oblique views, before the injection of lipiodol, in patients who are scheduled for spinal myelography. If the facets show a marked subluxation with evi-

dence of weight bearing, a facetectomy is indicated at the time the laminectomy is performed for the removal of the protruded disc.

10. Fractures of the articular facets are apt to cause persistent and severe low back pain. They are usually recognized in the oblique views, and as a rule are not seen in the routine anteroposterior and lateral views. Fractures of the articular facets must be distinguished from two important congenital anomalies: (a) accessory ossicles that occur at the tips of the articular facets; (b) congenital clefts (spondyloschisis) of the pars interarticularis and laminae of the neural arch.

REFERENCES

1. Bailey, W. Persistent vertebral process epiphyses. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 85–90.
2. Chandler, F. A. Lesions of the "isthmus" (pars interarticularis) of the laminae of the lower lumbar vertebrae and their relation to spondylolisthesis. *Surg., Gynec. & Obst.*, 1931, *53*, 273–306.
3. Ghormley, R. K., and Kirklin, B. R. Oblique view for demonstration of articular facets in lumbosacral backache and sciatic pain. Am. J. Roentgenol. & Rad. Therapy, 1834, *31*, 173–176.
4. Hadley, L. A. Subluxation of apophyseal articulations with bony impingement as a cause of back pain. Am. J. Roentgenol. & Rad. Therapy, 1935, *33*, 209–213.
5. Haggart, G. E. Early operation (spine fusion) in unstable lumbosacral joints. *J. Am. M. Ass.*, 1940, *115*, 2129–2132.
6. Horwitz, T., and Smith, R. M. An anatomical, pathological and roentgenological study of intervertebral joints of lumbar spine and of sacroiliac joints. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 173–186.
7. Hubeny, M. J. Oblique projection in examination of lumbar spine. *Radiology*, 1931, *16*, 720–724.
8. Morton, S. A. Value of the oblique view in radiographic examination of lumbar spine. *Radiology*, 1937, *29*, 568–573.
9. Mueller, W. Ueber eine Bemerkenswerte Form von Wirbelsäulenmissbildung. (Völliges Fehlen von Gelenkfortsätzen.) *München. med. Wchnschr.*, 1932, *79*, 356.
10. Oppenheimer, A. Apophyseal intervertebral articulations, roentgenologically considered. *Radiology*, 1938, *30*, 724–740.
11. Taylor, R. G. Anomalies of lumbosacral articulations. *J. Am. M. Ass.*, 1939, *113*, 463–465.
12. Willis, T. A. Separate neural arch. *J. Bone & Joint Surg.*, 1931, *12*, 709–721.

SPONTANEOUS PNEUMOMEDIASTINUM (MEDIASTINAL EMPHYSEMA)*

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MEDICAL literature reveals few reports of spontaneous pneumomediastinum. In fact, in discussing this condition with a number of physicians of rather wide experience, it was found that none had seen a case previously; at least they had not recognized it as such. However, Hamman's report of 7 cases in his own experience leads one to the assumption that the condition is not as rare as might be supposed.

As Hamman points out, physicians have long recognized the occurrence of interstitial emphysema of the lungs and mediastinal emphysema. But the spontaneous occurrence of these conditions seems not to have been recognized. The diagnosis was apparently made only when there was subcutaneous emphysema of the neck. The term "spontaneous" is reserved for those cases in which there is no evidence of injury or disease.

It is easy to understand the mechanism of the formation of interstitial emphysema of the lungs and mediastinal emphysema when they are associated with trauma. But the mechanism involved when there is no injury or unusual physical effort, and no evidence of disease, is more obscure. It may be assumed that there is a weakening of some of the alveolar walls, with rupture, but just why this should occur with no apparent injury or disease is not easy to understand. It may be that the alveolar walls have been damaged or weakened on some previous exertion, and that the actual rupture of the walls takes place later in a period of relative quiet. This condition has been produced experimentally by suddenly increasing the intrapulmonary pressure. Sections of the lungs revealed ruptures of many of the alveolar walls and distention of the interstitial tissue with air. Artificial pneumomediastinum has also been used both in treatment and in roentgenography. Montuschi has injected air into the anterior mediastinum in pulmonary tuberculosis, using this method only in those cases in which the lung lesion is mostly paramedian and anterior. Castellanos and Pereiras, following the work of Condorelli in 1936, have induced artificial pneumomediastinum to aid in differential diagnosis of pathologic conditions in the mediastinum, including the enlarged thymus. They state that the technique is easy and without risk.

Pathologically the process appears to begin with escape of air into the interstitial tissues of the lung from ruptured alveolar walls. The air passes along the connective tissue paths to the mediastinum. There has been some experimental evidence to show that the air follows along the sheaths of the arteries. As the air accumulates in the mediastinum, it collects around the vessel walls and between the heart and the anterior chest wall. It may also push out laterally, displacing one or both lungs away from the median line. In some instances the path of least resistance for the air may be toward the pleura. Hamman suggests that sometimes the air may work back from the mediastinum and reach the pleural cavity, producing a pneumothorax. This may explain the etiology of some of our spontaneous pneumothorax cases. As the pressure increases, there is frequently an infiltration of air up into the subcutaneous tissues of the neck. It is conceivable that the air may pass through the esophageal hiatus or along the vessel walls through the diaphragm to infiltrate the retroperitoneal tissues. If the mediastinal pressure becomes as great as that of the venous and intra-auricular pressure, circulation ceases.

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The symptomatology of spontaneous pneumomediastinum is striking. The onset is abrupt. The individual first notices a sharp pain which is usually located over the sternum. Sometimes it is over the left lower chest or in the left axillary region, and it may radiate down the left arm. One of the 7 cases reported by Hamman had pain in the right chest. One, a physician, described a "loud bubbling, crackling sound synchronous with the heart beat." The pain may come on with little or no effort on the part of the individual. He may be sitting, or lying down. It is characteristic of these cases that there is no injury or unusual effort involved. On physical examination the patient is obviously distressed and alarmed, and he usually attributes the pain to heart trouble. The respirations are shallow, as deep breathing increases the pain. On ausculation, Hamman describes the peculiar bubbling or crackling sound over the apex of the heart, and synchronous with the heart beat. This was present in all of his cases. On percussion the area of cardiac dullness is diminished or absent, due to the large collection of air in this region. The percussion note may even be hyperresonant. One of the striking findings is the presence of air in the subcutaneous tissues of the neck. Pneumothorax is sometimes present, and was associated with 2 of Hamman's cases, both on the left side.

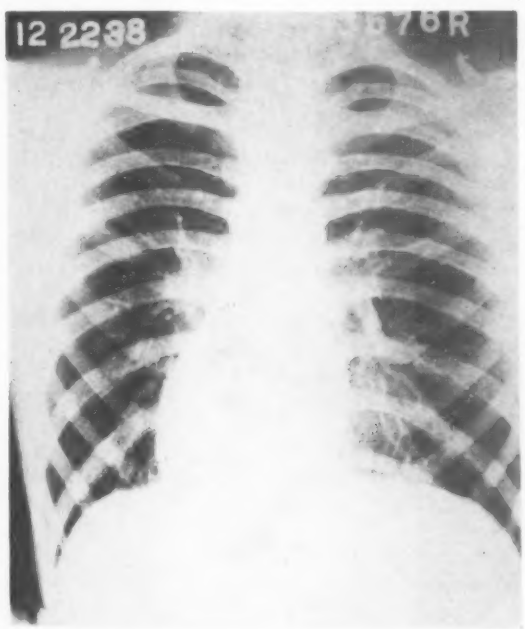

Fig. 1. Pneumomediastinum. Note narrow white line parallel with left border of cardiac shadow, extending from the pulmonic area to the diaphragm.

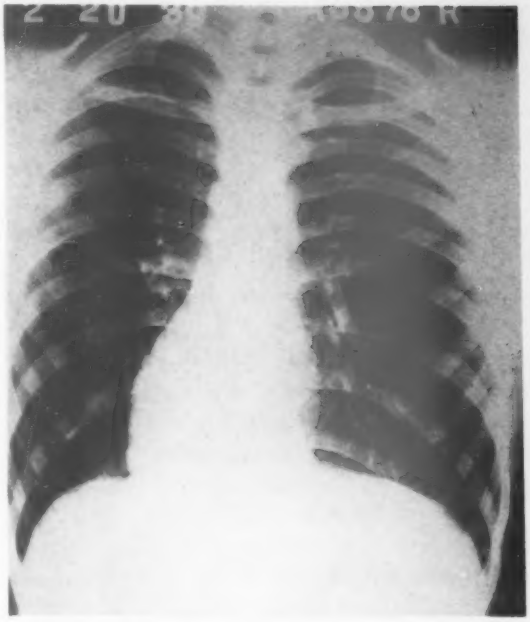

Fig. 2. Mediastinal air has disappeared. Patient entirely symptom free.

The general clinical picture is not one of shock. The temperature, pulse and respiratory rate are usually normal. The blood count and the electrocardiogram are normal. The roentgen findings are characteristic, when present. There is a white line paralleling one or both borders of the cardiac shadow. This line represents the border of the mediastinum as the lung is pushed out from behind the heart shadow. The lateral view shows a large air space between the heart and the anterior chest wall.

The principal condition to be considered in differential diagnosis is coronary disease. The sudden onset, with substernal pain as the predominant symptom, focuses attention immediately toward the coronary circulation. Angus M. Scott, of Glasgow,

has called attention to the significance of the anginal syndrome in spontaneous pneumomediastinum. The presence of the characteristic crackling sound over the apex of the heart, the presence of subcutaneous emphysema of the neck in the absence of injury, or the finding of the characteristic roentgen findings should establish the diagnosis when the cardiac and electrocardiographic findings are normal.

The treatment is essentially symptomatic: medication for relief of pain; rest in bed to avoid exertion with its attendant increased respiratory excursion. Withdrawal of some of the air may have to be resorted to, but usually is not necessary. As a rule, the condition clears up with appropriate treatment within two or three weeks.

CASE REPORT

Patient is a white male, aged twenty-two. On December 15, 1938, he experienced acute pain in the left chest, localized along the left border of the heart. The pain was so acute that he was unable to stand up straight. There was marked hyperesthesia over the area of pain, so much that he was unable to carry anything in the left pocket of his shirt. Patient did not have chills or fever. On December 17, 1938, he noticed the crepitation in the left supraclavicular region. The pain increased in severity and he came to the Out-Patient Clinic to see a doctor. He was hospitalized immediately. He was obviously in considerable distress, with shallow breathing. Pulse was normal. The respiratory rate was 28. Electrocardiogram was negative. A roentgenogram of the chest was made, and showed the characteristic parallel line along the left border of the heart (Fig. 1). There was none on the right. The patient did not show the characteristic sound over the apex of the heart at any time while under medical observation. He was kept at absolute rest in bed. The hyperesthesia over the left border of the heart existed in decreasing degree for a week. All crepitation in the left supraclavicular region had disappeared by December 25, 1938. By this time the patient had improved until he was able to breathe normally, stand up straight and move about without experiencing pain. Subsequent examinations at frequent intervals over a period of two months showed no recurrence of the trouble.

SUMMARY

1. The incidence of spontaneous pneumomediastinum is probably greater than previously supposed. Some of these cases have undoubtedly been diagnosed coronary disease.

2. The following signs and symptoms are cardinal points in diagnosis: (a) Sudden onset of severe pain over sternum or left chest. (b) Shallow breathing. (c) Subcutaneous emphysema of neck. (d) Characteristic "crackling" sound over apex of heart, synchronous with heart beat. (e) Characteristic roentgen findings. (f) Lack of cardiac dullness, or presence of hyperresonance over cardiac area. (g) Normal cardiac and electrocardiographic findings.

3. The treatment is symptomatic with complete rest in bed to avoid the increased pain accompanying movement and exertion. Withdrawal of air may be indicated in certain cases.

REFERENCES

1. Castellanos, A., and Pereiras, R. New method for diagnosis of hypertrophy of the thymus in infancy. *Arch. de la Soc. de estud. clin. de la Havana*, 1938, *32*, 421.
2. Hamman, L. Spontaneous mediastinal emphysema. *Bull. Johns Hopkins Hosp.*, 1939, *64*, 1–21.
3. Jehn, W. Das Mediastinalemphysem. *Zentralbl. f. Chir.*, 1921, *48*, 1619–1623.
4. Jehn, W., and Nissen, R. Pathologie und Klinik des Mediastinalemphysems. *Deutsche Ztschr. f. Chir.*, 1927, *206*, 221–245.
5. Jessup, P. M. Mediastinal emphysema. *Arch. Surg.*, 1931, *23*, 760–782.
6. Kelman, S. R. Experimental emphysema. *Arch. Int. Med.*, 1919, *24*, 332.
7. Macklin, C. C. Pneumothorax with massive collapse from experimental local over-inflation of the lung substance. *Canad. M. Ass. J.*, 1937, *36*, 414–420.
8. Montuschi, E. Chronic pulmonary tuberculosis treated by introduction of air into anterior mediastinum (artificial pneumomediastinum). *Proc. Roy. Soc. Med.*, 1938, *31*, 919.
9. Scott, A. M. Significance of anginal syndrome in acute spontaneous pneumomediastinum. *Lancet*, 1937, *1*, 1327–1330.

Vol. 48, No. 4

PATELLA CUBITI

A REPORT OF FOUR CASES

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IN THE "Consolidated Indices" which cover completely by subject and author index all of the publications of the American Roentgen Ray Society and in addition a large number of abstracts from American and foreign journals from the years 1903 to 1937 inclusive (some 35,000 pages of material being included) there is a single reference to the subject of patella cubiti. This reference is found in an abstract of an original article contributed by Dr. Philip Lewin of Chicago in the January, 1929, number of the *American Journal of Diseases of Children*. The subject of this paper was "Epiphyses; their growth, development, injuries and diseases." In his discussion of patella cubiti the author merely states that "patella cubiti is a condition described by Gunn in the British Journal of Surgery." No description is given of the condition nor is there any opinion stated as to its etiology. It would appear probable that at least up to the date of that writing Lewin had had no personal experience with this rare elbow condition and therefore presumably had no opinion regarding its etiology. In the article on the subject contributed by Gunn in 1928, the writer who presented a single case consulted Sir Robert Jones who stated that in all of his personal experience he had never seen a similar case. Gunn's case of patella cubiti was decidedly unusual. His patient, a woman aged forty-six, gave no history of previous elbow injury; on roentgen examination made four days following an injury resulting from being knocked down by a bicycle, she was found to have a fracture through the upper end of the ulna extending into the articular surface, but above the level of fracture the appearance of patella cubiti was also found. In the course of re-examination of Gunn's case four months after the injury there was the expected bony union at the site of fracture whereas the appearance of the cubital patella was unchanged. Gunn concluded that the unusual appearance found was to be attributed in this case to "one of persistent separation of the olecranon epiphysis." In support of this theory he included a third illustration in his article, that of a boy aged twelve showing three separate ossific centers (one large and two small ones) for the olecranon.

The idea of the patella possessing a homologue in the elbow region was first mentioned in the European anatomy according to Eisler but found by Vicq d'Azyr in 1774 and by Meckel in 1915. Hoernle showed that the Hindu anatomy four or five hundred years B.C. had the same idea. By the ancient Indian anatomist the olecranon process was counted as a separate bone. Reeves quotes Gegenbaur as advancing the view that the olecranon corresponds with the patella but Quain holds that the patella has no homologue in the human body.

Cunningham in his 1923 edition recorded one case of the olecranon as a separate bone.

The late Dr. F. J. Cotton of Boston was probably the first to report a case of cubital patella, a description of the diagnosis, treatment, and end-results of 2 cases being reported in the *Boston Medical and Surgical Journal* in 1900. He did not use the term patella cubiti, the title of his paper being merely "Separation of the epiphysis of the olecranon." The first case was that of a sailor, aged sixteen, the second occurred in a lad, aged eleven. Both gave histories of recent falls but only on the hand, no blow being sustained at the elbow level. Hence in both these cases the separation must have occurred as the result of triceps action. In the first case Cotton described a "skiagraph" as showing the olecranon

epiphysis displaced "upward and forward, the separation amounting to about one-third inch." In the second case the separation determined by physical examination was about one-eight inch; in the roentgenogram "the displacement was not notable." Cotton emphasized the anatomy of triceps insertion, most of which is on the epiphysis, but part of the tendinous expansion extends distally into the fascia on either side, hence despite more or less complete tear of the epiphyseal cartilage, the separation of epiphysis from diaphysis may be slight. Cotton states, "In a short search of the literature I have found no other case recorded where this separation occurred without other injury." Cotton quoted Poland, Gueretin, and Salmon, saying that experimentally the injury was produced by forcible hyperextension but added that "one can not readily imitate on the cadaver, muscular action resisting flexion," the probable mechanism of cases occurring clinically.

Kienböck reported a case in 1903 of a large patella-like sesamoid bone above each olecranon. The history was that of an injury to the left elbow at the age of seventeen and a later injury was sustained to the right elbow (year not stated). Furthermore the inferred relationship between these injuries in late adolescence and the abnormalities noted was not indicated. Kienböck contributed with Desenfans a further article on the subject in 1937, at which time 3 cases of patella cubiti were reported. Whereas Kienböck originally designated the condition as patella cubiti, in this article the term "os epiphysaire de l'olecrane" was advocated. There were 2 new cases reported by these authors. The first was that of a miner, aged twenty-eight, who gave no history of preceding pathologic condition, who had injured his right elbow nine months previously. The elbow was found to be slightly swollen, with limitation of motion in extension, but the examination of the left elbow showed the same morphology and the same limitation of motion in extension. Roentgenographically the patella cubiti was located in the tendon of the brachial triceps and was about the size of a chestnut. The two articular facets of the patella cubiti had a covering of hyaline cartilage. The two elbows were identical except that the right elbow was slightly swollen. The patella cubiti of the right elbow showed slight separation as if it were produced by a dislocation of this articulation as a result of the trauma. Several members of the family of this individual were examined and in the father, aged sixty, who denied trauma to the right elbow, an anomaly was found similar to that of the son. Kienböck and Desenfans emphasized the same point which was made by Gunn, namely on the side of the anomaly the ulna including the patella cubiti is longer than the ulna on the side wherein the anomaly does not exist. They consider this as evidence in favor of the congenital anomaly theory. They quote some ten other authors who have contributed to this subject, namely Katz, Pauley, Japiot, Gunn, Beykerch, Rostock, Ewald, Kremser, and Odessey and Melinhowa. From their review of the literature they find these authors divided between the theory of traumatic origin and the theory of congenital anomaly. Several of these writers emphasize the possibility of more than one center of ossification for the olecranon and indicate that this may serve as a basis for the occasional persistence of a separate center of ossification.

Desenfans has recently observed a further case but this remains unpublished and no information is available as to its etiology.

In a recent contribution on fractures and dislocations involving the elbow joints in children, Robertson states that "Fracture of the olecranon is not important. The injury is not found in children. It occurs more frequently in adults. In those cases it is frequently necessary to do open reduction."

DeBrun in his recently published manual of "Fractures, Dislocations, and Epiphyseal Separations" makes no mention of

detachment or separation of the ephiphysis of the upper end of the ulna or of the occasional presence of a double center of ossification for the olecranon epiphysis.

In an article by Zeitlin, a single case of patella cubiti is recorded which corresponds quite closely in appearance to Case II of my 4 cases. Zeitlin merely states that "there was no indication of recent trauma but an arthrosis deformans existed." There is no definite statement to the effect that nothing to do with causing the accessory bone. There is no loss of function of the joint." These conclusions do not appear completely tenable. Zeitlin is apparently not aware that quite regularly patella cubiti is associated with some limitation of extension of the elbow. Furthermore he misquotes Gunn as being of the opinion that patella cubiti is a result of "traumatic avulsion of the ossification center in early childhood."

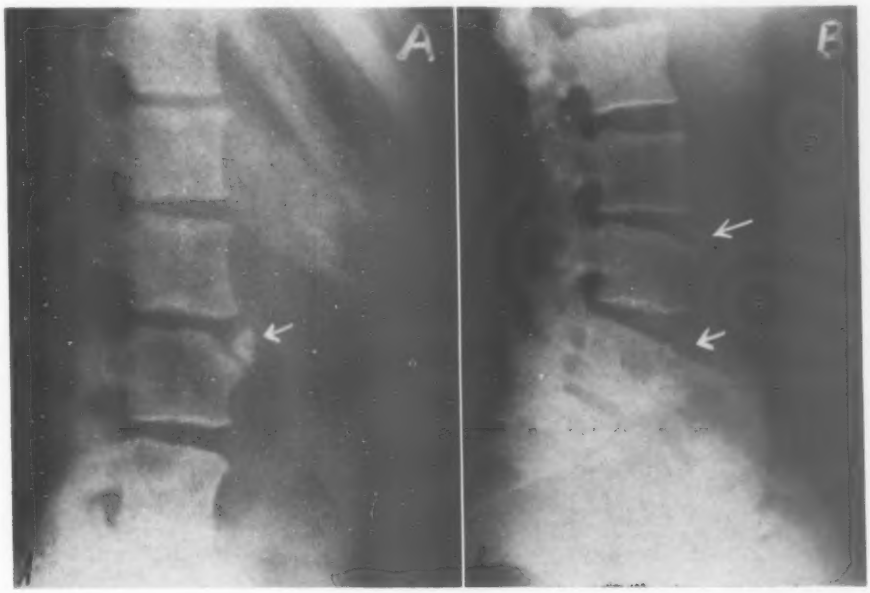

FIG. 1. *A*, growth disturbance of secondary epiphysis, sometimes termed "epiphysitis." As in patella cubiti the over-all dimensions of the abnormal bones are larger than of the normal bone. *B*, "epiphysitis" affecting fourth and fifth lumbar vertebrae. The olecranon epiphysis and the vertebral body margin epiphysis begin and complete ossification at about the same age periods. Both patella cubiti and this type of vertebral "epiphysitis" are encountered in individuals with negative histories as regards childhood trauma.

ancient trauma was recalled, yet in the conclusions of this article which dealt more at length with avulsions of the humeral epicondyles, the author draws general conclusions that "an isolated rounded bone near the medial humeral epicondyle and the so-called cubital patella are traumatic in origin. They are the result of a separation of the epiphyseal ossification center in early childhood without subsequent absorption and with independent further development. The theory of congenital origin is not convincing. Recent trauma has

Recently a further contribution to the subject was made by Kremser. This writer had in 1934 reported a single instance of elbow patella or patella cubiti, and on the basis of the history and findings in that case plus a review of the literature he concluded that the etiology was that of a developmental anomaly. However, in his recent contribution he comes to the conclusion that "without doubt the possibility of a traumatic origin of elbow patella" must also be considered. In this article he reports the case of a child, aged fourteen,

who suffered an elbow injury shortly before the first roentgen examination. On the first roentgenogram there was seen an appearance of a thin curved plate of bone apparently torn from the proximal end of the olecranon epiphysis and displaced rather widely upward. The remainder of the olecranon showed apparently normal relationship with the shaft of the ulna. On re-examination two years later the olecranon ossification was found complete and at about the level of the original bone chip the olecranon with wide separation of the chip showed on late re-examination a quadrilateral mass of bone just above the olecranon proper having some of the appearances of patella cubiti, the chip being considerably enlarged subsequent to the trauma, with pseudarthrosis formation.

Quite recently Theising reported 2 new cases which he considered to be cubital patella to be added to the 22 cases which he found in the literature. The first 4 cases were from anatomical material, the first

Fig. 2. Patella bipartita, a condition rather generally accepted as an anomaly. Note similar features in left patella to patella cubiti, Case 11, herein reported, namely small areas of rarefaction adjacent to line of division, and note over-all dimensions of bipartite patella to be larger than a normal patella.

there now appeared "a sharply defined mass of bone which is separated from the olecranon by a wide light zone. It is shaped like a sesamoid bone." Even with this evidence of apparent traumatic origin of the cubital patella in this case Kremser states further: "My original opinion that the traumatic origin of a patella cubiti is a rare occurrence is not contradicted by the above-mentioned case." He then refers to a further case of elbow injury and illustrates it with roentgenograms made shortly after the injury and again some time thereafter which appeared in an adult, a female aged fifty-four, who, following a chip fracture of being in the year 1776 and the second by Virchow in 1864, the third by Tillesson in 1874 and the fourth by Pfitzner in 1892. Of the 22 cases previously reported all were in men while 1 of the 2 new cases was a woman, a restaurant worker. It is further interesting to note that 6 showed bilateral changes, including 2 of Kienböck's 3 cases. The youngest age was the case reported by Pauly, which was found in a male aged eighteen, and the lesion was bilateral. Theising definitely considers trauma to be the etiologic factor. Rather obviously trauma was the factor in his 2 cases but they do not appear typical of patella cubiti

as I have seen it. In his first case the injury occurred in a woman, aged fifty-five, and in the second, in a man aged fifty. The first case showed detachment of a fragment of the olecranon measuring 12 by 4 mm. which six months later showed increase in size to 30 by 20 by 20 mm. The second case studied roentgenographically for the first time thirteen years after the injury likewise showed a mass of detached bone on the posterior side of the elbow measuring 30 by 20 by 20 mm. If the 2 cases reported by Theising are to be accepted as true instances of patella cubiti then any fracture of the olecranon or a part of the process which fails to undergo union but instead forms a pseudo-articulation, particularly if it increases in size, might be listed as an additional case of cubital patella. Rather in the true case of patella cubiti there will be either no history of trauma pertinent to the finding or the trauma will have occurred *in childhood*.

That appearances more or less closely simulating true patella cubiti are much less rare than the typical condition is illustrated again in a reproduction of a roentgenogram in Ferguson's monograph, in which considerable soft tissue calcification both in the cubital fossa and just proximal to the olecranon occurred in a female aged thirty-five, eight months following trauma.

FIG. 3. Two instances of double centers of ossification of the olecranon process. *A*, male, aged fourteen, recent trauma, roentgen findings negative for bony trauma. *B*, female, aged thirteen, recent trauma resulting in greenstick fracture mid shaft of the radius (courtesy of Dr. I. Cowan).

That there are therefore conditions somewhat resembling patella cubiti, which are obviously of traumatic origin, need not be debated but that the typical true condition of patella cubiti, a decided rarity, as indicated by the lack of reports in the American roentgenologic literature, may be either of developmental anomaly origin or of traumatic origin still appears likely and some support of this theory would appear

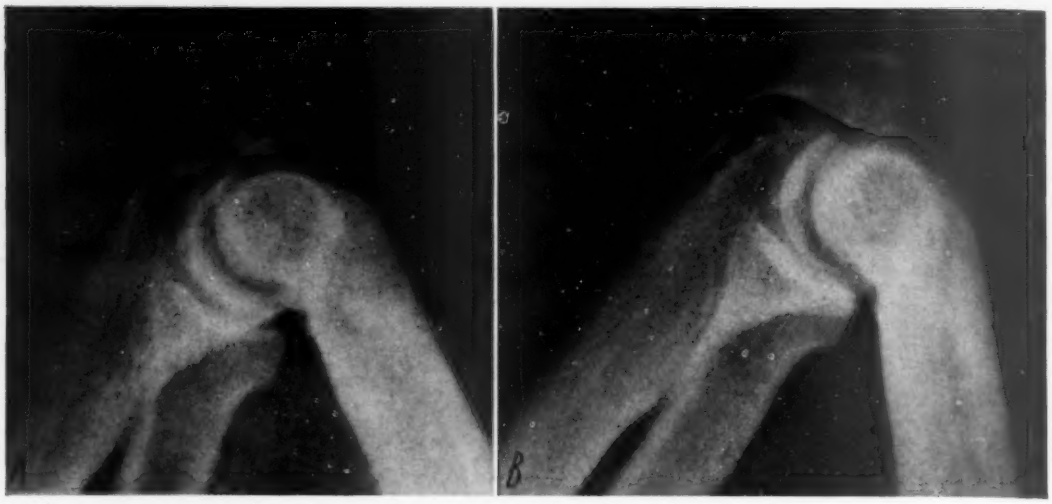

Fig. 4. Case 1. *A*, male, aged twenty-two. First roentgen study October 2, 1936, several days after minor injury to right elbow. At age of fourteen the same elbow was injured while playing basketball. Roentgenograms were said to show a fracture. *B*, re-examination July 22, 1938, showed no change in appearance of segmented patella cubiti.

to be offered from the history of at least 1 of the 4 cases herein reported.

We would mention a third possible explanation of the etiology of patella cubiti and that is an "epiphysitis" of the olecranon. Lewin said, "Epiphysitis or osteochondritis of the olecranon process undoubtedly occurs but to my knowledge has never been described." I have seen a number of cases of so-called epiphysitis of the lumbar vertebral bodies and have been impressed with the similarity of these growth disturbances resulting in ununited rim bands along one or several margins of the lumbar vertebrae, and the condition of true patella cubiti in the elbow. In the former group of cases there has been almost universal absence of any history of injury in childhood, particularly during that interval subsequent to the beginning ossification of the vertebral body margins which usually occurs at the age of nine or ten and union with the body proper which occurs at about the age of sixteen to eighteen years. We have, furthermore, observed enough instances of fractures involving the bodies of the dorsal or lumbar vertebrae in older children and adolescents to know the extreme rarity of a traumatic separation of the epiphysis for the vertebral body margins. Ferguson in his monograph illustrates just one such a case.

It might be further pointed out that these secondary epiphyses for the vertebral body margins, like the epiphysis (ses) for the olecranon, undergo initial ossification at about the same year (nine to twelve) and normally unite with the primary center at about the same age of fifteen to eighteen years. One of the 3 cases of cubital patella here reported was examined for evidence of "epiphysitis" or epiphyseal growth disturbances in other parts of the skeleton and slight evidences for such growth disturbances of the secondary epiphyses of the eleventh dorsal and third and fifth lumbar vertebrae were found.

There is a further similarity between patella cubiti, patella bipartita, and so-called "epiphysitis" of the (usually lower lumbar) vertebral body margin, namely the primary center or main portion of the bone plus the anomaly or ununited epiphysis, together constitute a larger or longer structure than in the normal opposite ulna or adjacent vertebra.

If it can be accepted that patella cubiti results from avulsion fracture of the ole-

cranon epiphysis, then it is interesting to note that it gives rise to an opposite situation to that ordinarily occurring in this type of fracture. Compere and others have studied particularly the effects of fractures that include epiphyses and these writers stress the danger of *arrested* growth. Is the explanation simply that the olecranon epiphysis is an exception to the rule because of its having an extensor muscle attached to it? If this is the answer then there should be other exceptions, as, for example, the greater trochanter of the femur. Again, as indication of the rarity of olecranon separations, in Compere's series of 290 fractures in children, of which there were 37 cases involving the epiphysis or the epiphyseal cartilage, there were only 2 in the ulna and these were both at the lower end of the bone.

REPORT OF CASES

Case 1. F. B., male, aged twenty-two, complained of recent minor injury of the right elbow followed by slight soreness in the part. The patient works in a garage and uses the wrists and elbows quite frequently at moderately heavy manual labor.

In 1928, at the age of fourteen, while playing basketball he injured the elbow while jumping for the ball. Roentgenograms were taken by the family physician and were said to show a fracture. Need it be emphasized that at this particular age some six epiphyseal cartilage lines are visualized in the ends of the bones entering into the formation of the elbow, any one of which might have been misinterpreted as a fracture by the inexperienced interpreter. Unfortunately, the physician attending the boy is deceased and no records or roentgenograms were preserved, hence it was impossible to obtain the original films for a review.

The part was immobilized in a splint. Following the injury the patient states that he has been unable to completely extend the right elbow.

Orthopedic examination showed a hard, bony mass the size of a large walnut just proximal to the olecranon. The area was not tender and it moved with the olecranon so that with the elbow flexed there was a double tip to the elbow. The distal prominence is slightly tender.

Fig. 5. Case 1. *A*, right elbow in maximum extension showing limitation of extension at 145°. *B*, normal left elbow, same patient.

FIG. 6. Case II. Male, aged thirty-three, roentgen examination June 1, 1938, one day after alleged injury right elbow from fall on hand. Denies any previous injury. Impression of first interpreter of films was "pathologic fracture."

A limitation of extension of approximately 15° was noted. The circumference of the right elbow was 1 cm. greater than that of the left.

Roentgen examination at this time, October 2, 1936, showed a large tongue-like mass of bone measuring about 5.5 cm. in greatest length by 2.5 cm. in width by 2 cm. in maximum thickness, closely approximated to and more or less surrounding a rather rudimentary short olecranon process proper of the ulna in this arm. The difference in length of the olecranon process proper in the right elbow and in the normal left elbow is approximately 15 cm. About 1.5 cm. from the distal end of the patella-like structure a line of diminished density is seen extending across the mass of bone, resulting in a segmented form. The appearance is not considered suggestive of a recent fracture. Re-examination of the right elbow region approximately twenty-two months later, on July 22, 1938, revealed an absolutely unchanged appearance of the cubital patella, and of all of the other structures in the right elbow region. In this individual it is to be emphasized that the cubital patella showed no appreciable change in its relationship to the ulna between extreme flexion and extension but that there is free motion between the cubital patella and olecranon fossa on the posterior aspect of the humerus much the same as there is free motion between the patella and the articular surface of the femur. In this patient we find roentgenologically the maximum extension of the elbow to be 145° and maximum flexion 35°.

This man continues steadily at his work as a garage mechanic and a recent clinical progress note merely stated that occasionally slight discomfort was noted in the elbow following minor trauma to it.

CASE II. The elbow films of I. W., male, aged thirty-three, were examined at the request of an insurance company in early July, 1938, the claimant giving a history of having fallen on the right hand while at work May 31, 1938. The original roentgenograms were taken June 1, the day following injury, and further films were made June 8, eight days following trauma. Clinically the arm was said to show some "swelling" at the right elbow level but no discoloration. Flexion and extension were found slightly limited. The examination of the films

FIG. 7. Case 11. Re-examination of right elbow August 3, 1939, in maximum extension, *A*, and flexion, *B*. Some motion between the patella and the ulna proper is shown on the acute flexion study.

showed a normal left elbow while the right showed an appearance typical of patella cubiti, the accessory bone in this instance measuring approximately 3.5 cm. in length by 3 cm. in width by 1.5 cm. in maximum thickness, the ossicle being closely approximated to the ulna proper and showing no appreciable separation from it when the position of the part was changed from about 70° flexion to about 107° extension. Distal to the patella cubiti the adjacent ulna proper showed small cystic areas of rarefaction (note similarity of these cystic areas in diaphysis of ulna to like areas in opposing margins of larger part of patella bipartita, Fig. 2). In this individual, too, there was therefore nothing to suggest recent bony trauma nor any appearance of traumatic separation of the bony anomaly from the ulna proper. This individual persistently denied all previous trauma to the right elbow. After a few weeks' rest the patient returned to work but alleged persistent discomfort in the part.

The same patient was re-examined on August 3, 1939, approximately fourteen months after the known and acknowledged trauma to the right elbow. There was absolutely no change in the appearance of the cubital patella or of the ulna just distal to it. On the recent examination, observations regarding the relationship of the

FIG. 8. Case 11. On searching other likely parts of the skeleton for any growth disturbances, minor ones were demonstrated on the inferior margins of the eleventh dorsal and the anterosuperior borders of the third and fifth lumbar vertebral bodies.

patella and of the ulna proper were made with the part in maximum flexion and maximum extension, this not having previously been done. On this examination the angle of maximum extension was found to be 150° and maximum flexion 40°. With the part in extreme flexion a somewhat wider separation of the patella from the ulna proper occurred.

This patient was then examined rather extensively for any evidence of ununited epiphyseal structure or "epiphysitis" in other parts of the body, the examination including both knee patellae, both hip joints, and the lower dorsal and lumbar spine. In the latter area there was found some limited confirmation of the theory of developmental anomaly or growth disturbance of the secondary epiphyses since at the upper anterior margins of the third and fifth lumbar vertebrae there were findings of very slight growth disturbances in the vicinity of the epiphysis for the body margin and on the inferior margin of the eleventh dorsal vertebra there was a further finding of slight growth disturbances at both the anterior and posterior margins of the rim band.

This man continued his work as a foreman on a cranberry farm, apparently with no work disability from the elbow anomaly, until December, 1939, when he died as a result of a deer hunting accident.

CASE III. C. C., male, aged fifteeen, was playing football October 18, 1939. He was carrying the ball in the usual manner, tucked between his left arm and body and was "bumped out of bounds" and struck the olecranon region of his acutely flexed elbow on the railing of a fence. The elbow pained moderately, but the patient found he could use the part rather well and the family physician was not consulted until about three weeks after the injury. It was observed and treated ten days further before the family brought the boy to the hospital for roentgen study as had been directed by the attending physician. At this time, as indicated by the accompanying roentgenograms, he had a nearly normal range of flexion and extension but there was some weakness of power in extension and there was a bony prominence on the posterior aspect of the injured joint. The circumference of the injured joint was 1.5 cm. greater than the uninjured right elbow, and the enlargement seemed bony rather than soft tissue in nature. Because of the rather late date after trauma before the first roentgenogram was obtained it is somewhat difficult to determine whether the

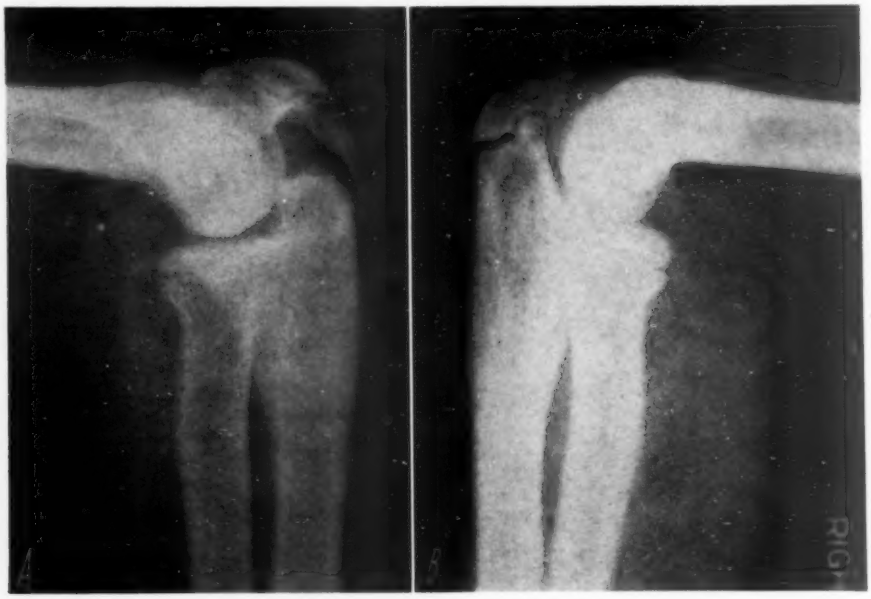

FIG. 9. Case III. *A*, male, aged fifteen, injured left elbow while running with a football. First roentgen study made November 23, 1939. *B*, uninjured elbow for comparison. Olecranon epiphyseal line anomalous with small acessory center of ossification at proximal end.

anatomy of the injured joint was strictly normal prior to the injury of October 18, 1939, or anomalous. There can be no reasonable doubt, however, that in this instance the patella cubiti, in an early stage of formation, resulted from a traumatic separation of the olecranon epiphysis.

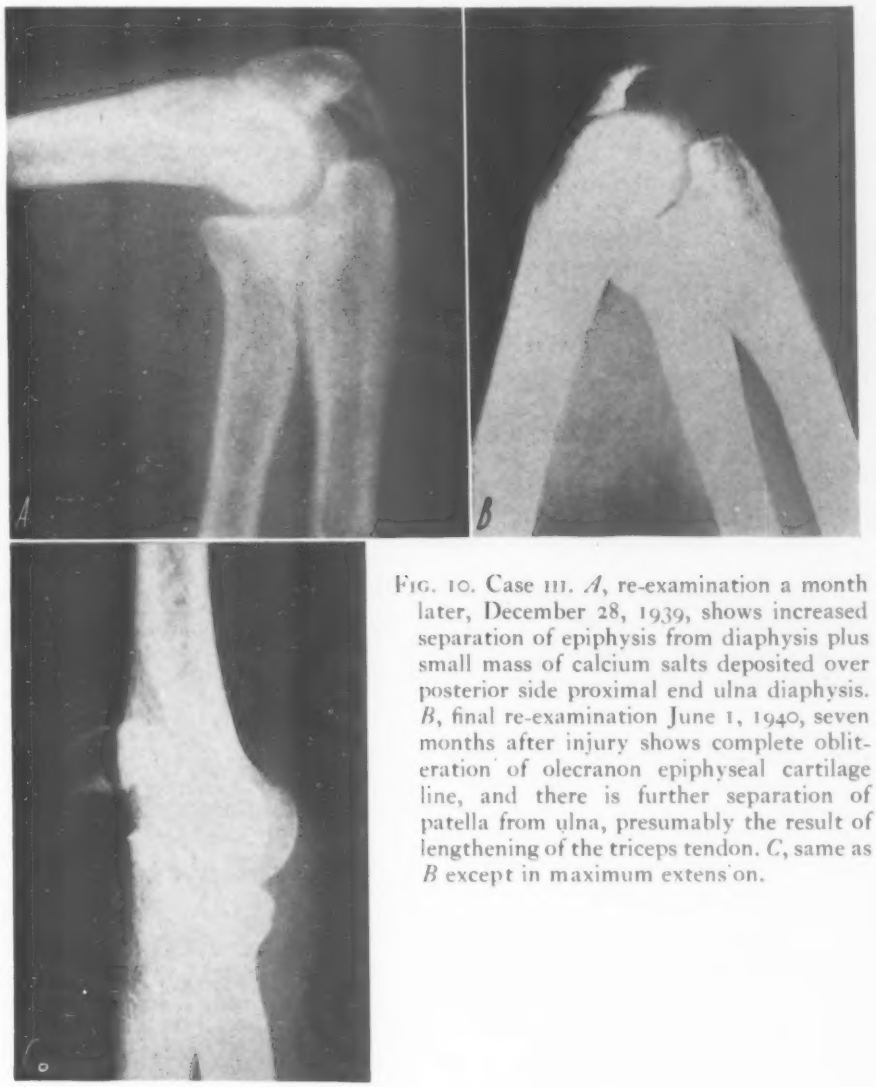

FIG. 10. Case III. *A*, re-examination a month later, December 28, 1939, shows increased separation of epiphysis from diaphysis plus small mass of calcium salts deposited over posterior side proximal end ulna diaphysis. *B*, final re-examination June 1, 1940, seven months after injury shows complete obliteration of olecranon epiphyseal cartilage line, and there is further separation of patella from ulna, presumably the result of lengthening of the triceps tendon. *C*, same as *B* except in maximum extension.

The re-examination done about one month later showed slightly greater separation of the olecranon epiphysis from the diaphysis, this finding suggesting progressive separation or elongation of the triceps tendon. (Due to the late date of starting treatment, the part had not been immobilized but its use merely restricted by a sling.) There had also developed a small mass of calcium deposit just proximal to the tongue-like projection attached to the proximal end of the olecranon epiphysis, indicating reparative changes to be continuing. A surgical repair of the separation to relieve the weakness of the power of extension was recommended, but was not accepted.

Still further re-examination made June 1, 1940, seven and one-half months after the injury, showed definite further change in the appearance of the detached olecranon epiphysis, the epiphyseal cartilage line separating the epiphysis proper from the bone distal to it having completely disappeared and this separated mass of bone having a smooth configura-

tion with joint-like surface which latter undoubtedly acts as an articular surface against the proximal end of the olecranon diaphysis. The distal end of what may now be designated a recently developed patella cubiti has undergone further separation from the shallow fossa on the posterior aspect of the proximal shaft of the olecranon.

Additional films were made of the patellae, the feet, and the lower spine to determine evidences of anomaly or epiphysitis elsewhere in the skeleton, but except for the presence of a medium large os tibiale externum near the medial end of either tarsal scaphoid no such abnormalities were found.

Clinically there was still a measurable enlargement of the left elbow as compared with the right, the circumference of the left being 24.5 cm. and of the right 24.0 cm. Furthermore, there was also a definite weakness of the power of extension of the left elbow (the maximum range of motion determined roentgenographically was 35° flexion to 175° extension).

The end-result in this case will probably resemble closely that of Case I.

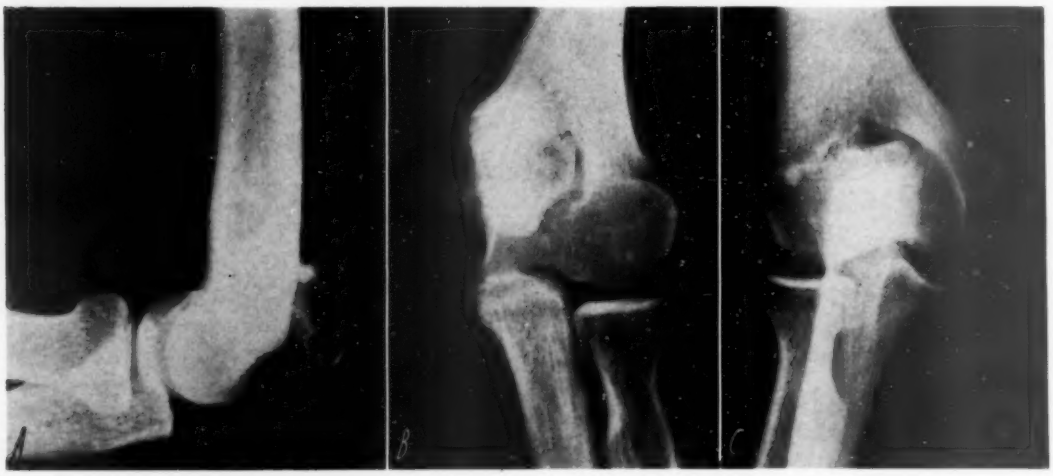

Fig. 11. Case IV. *A*, male, aged twenty-three, recent minor trauma, struck elbow on corner of bench. At the age of eight or nine injured the same elbow when he jumped from a bench and struck "tip of elbow" on the concrete. Did not consult physician, carried arm in home-made sling about three to four weeks after which he could use it reasonably well. See normal elbow, *C*, for comparison. *B*, anteroposterior study, recently injured left elbow (earlier injury age eight or nine). *C*, right elbow for comparison (no recent or old injuries).

Case IV. A. B., male, aged twenty-three, stated that on October 29, 1940, while working, he struck his elbow on the corner of a work bench. The following day be noticed swelling and experienced pain on certain movements, particularly when lifting or holding the arm above the head. When questioned regarding previous injury he stated that approximately fifteen years ago, or at the age of eight or nine years, he had injured the elbow by jumping from a bench and striking the "tip of the elbow" on a concrete pavement. He saw no physician at that time but merely carried the arm in a sling for three or four weeks and so far as he knew he made a satisfactory recovery although he has always been aware of a "bump" on the elbow since that time.

The elbow circumference on the left side was definitely greater than that on the right and a bony mass was palpable posteriorly in the olecranon fossa but there was no appearance of contusion or hematoma.

Roentgen examination made October 31, two days after the injury, showed no appearance of recent fracture or joint luxation. The large mass of bone representing an over-developed olecranon process and measuring approximately 3 by 2.5 by 2.5 cm. was seen impressed rather more deeply than normal into the olecranon fossa with some sclerotic reaction in the fossa. The upper end of the ulna proper is of unusual, flat configuration, the tip of the coronoid process representing the most proximal point of the bone. The assumption seems justified

then that the injury occurring fifteen years ago resulted in a separation in the olecranon fossa at the epiphyseal line or perhaps even a little distance distal to it with subsequent wide separation of the epiphyseal structure from the shaft of the bone.

SUMMARY AND CONCLUSIONS

Four cases of patella cubiti are reported. Each of the cases occurred as unilateral abnormality. Particular attention was devoted to the probable etiology. In the third case there can be little doubt that trauma was the chief if not the only factor giving rise to the abnormality, which was found in an individual, aged fifteen, about five weeks after trauma and which condition was followed for a period of six months, or until a relatively mature state of patella cubiti had occurred.

In the first case there was a definite history of trauma to the right elbow when the individual was fourteen years of age, the only recalled diagnosis being that of a "fracture." Every effort was made to locate the original roentgenograms or as a second choice the record of the roentgen interpretation but unfortunately the physician who attended the patient is deceased and there were no records available on this patient. One would be inclined to suppose that an avulsion of the olecranon epiphysis did occur together with periosteal stripping on the proximal diaphysis of the shaft by the mechanism of muscle pull, which was then followed by closure of the epiphysis and new bone formation along the tongue distal projection, much as was demonstrated in the several roentgen studies of Case III. In any event the minor trauma which occurred at age twenty-two which brought the condition of patella cubiti to light, had no bearing on the development of the bony abnormality and apparently none of the immediate or subsequent functional status of the elbow joint.

The fourth case is quite like the second as regards the history of a childhood trauma occurring at or about the time of beginning ossification of the olecranon epiphysis. In this case, however, the individual made a relatively satisfactory clinical recovery without benefit of medical examination and treatment.

In the third case reported, the past history was absolutely negative for elbow trauma and the only acknowledged trauma, occurring as it did at the age of thirty-three, very obviously had no relationship to the anomaly found. In this individual rather extensive roentgenographic studies of the other parts of the skeleton were made which showed minor developmental disturbances affecting the epiphyses for the body margins of the eleventh dorsal and third and fifth lumbar vertebrae. Attention is called to the fact that the epiphysis for the olecranon and the epiphyses for the vertebral body margins ossify at about the same age (nine to twelve years) and fuse with the remainder of their respective bones at about the same time (fifteen to eighteen years). Furthermore, there is a rather generally recognized rarity of epiphyseal fractures involving the olecranon and the vertebral body borders in children as evidenced by lack of any consideration whatever of the subject of olecranon injuries in childhood in recent articles devoted to elbow injuries in children. Cases of proved fracture or separations of the vertebral epiphyses are more rare than cases of "epiphysitis" or epiphyseal growth disturbance, demonstrable in individuals who give no history of significant back trauma.

While it was therefore possible in three of the four cases of patella cubiti here reported to show an etiologic relationship between childhood trauma and the formation of the patella, there may still be some doubt as to trauma being the only etiologic factor in all cases. The similarity of the so-called "epiphysitis" in other regions, both from the standpoint of the normal growth of these secondary epiphyses and from the standpoint of their roentgenologic appearances in the presence of a growth disturbance, is emphasized.

It may be stated with greater certainty

that in true patella cubiti any trauma factor significant to the development of the condition must be one occurring in childhood or adolescence. Hence trauma occurring in an adult employee who shows such an abnormality is *not* a causative factor in its appearance and the misinterpretation of "fracture" or "pathological fracture" should not be made.

REFERENCES

1. ATSATT, R. F. Loose bodies in the elbow joint. *J. Bone & Joint Surg.*, 1933, *15*, 1008–1009.
2. COMPERE, E. L. Growth arrest in long bones as the result of fractures that include the epiphysis. *J. Am. M. Ass.*, 1935, *105*, 2140–2146.
3. COTTON, F. J. Separation of epiphysis of the olecranon. *Boston M. & S. J.*, 1900, *42*, 692–694.
4. DESENFANS, G. Personal communication.
5. DEBRUN, H. C. Fractures, Dislocations and Epiphyseal Separations. Year Book Publishers, 1939.
6. GUNN, G. Patella cubiti. *Brit. J. Surg.*, 1928, *15*, 612–615.
7. ELIOT, E., JR. Fractures of the olecranon. *Surg. Clin. North America*, 1934, *14*, 487–492.
8. ERB, K. Ueber den Vorkommen freier und gestielter Knochenkörper in der Fossa olecrani und ihre Beziehungen zum Foramen supratrochleare. *Arch. f. klin. Chir.*, 1936, *185*, 482–492.
9. FERGUSON, A. B. Roentgen Diagnosis of the Spine and Extremities. *Ann. Roentgenol.*, Vol. XVII. Paul B. Hoeber, Inc., New York, 1939.
10. KIENBÖCK, R. *Wien. klin. Wchnschr.*, 1903, p. 634.
11. KIENBÖCK, R., and DESENFANS, G. Über Anomalien am Ellbogengelenk. Patella cubiti. *Beitr. z. klin. Chir.*, 1937, *165*, 524–529.
12. KIENBÖCK, R., and DESENFANS. Anomalie du squelette de l'articulation du coude, os sésamoïde du cubitus. *Presse méd.*, 1937, *45*, 491–492.
13. KREMSER, K. Ein weiterer Beitrag zum Kapitel der Ellenbogenscheibe. *Röntgenpraxis*, 1938, *10*, 841–844.
14. LEWIN, P. Epiphyses; their growth, development, injuries and diseases. *Am. J. Dis. Child.*, 1929, *37*, 141–178.
15. ROBERTSON, D. E. Fractures and dislocations involving the elbow joint in children. *Am. J. Surg.*, 1938, *39*, 327–333.
16. THEISING, G. Zur Kenntnis der Patella cubiti (Ellenbogenscheibe). *Röntgenpraxis*, 1939, *11*, 663–675.
17. ZEITLIN, A. Traumatic origin of accessory bones at the elbow. *J. Bone & Joint Surg.*, 1935, *17*, 933–938.

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THE PROBLEM OF THE "TUBAL SPHINCTER" AND OF THE INTRAMURAL PORTION OF THE FALLOPIAN TUBE

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AS A result of insistent recommendation by Heuser at various congresses* that lipiodol be used as a contrast medium for roentgen visualization of the uterine cavity, many physicians were first stimulated to undertake the use of this then new method. Soon after, in 1926, a constriction of the roentgen shadow at the uterotubal angle was described by the author in collaboration with Eisler, as well as by others† in three independent communications at almost the same time. This phenomenon was conceived by all four authors to be an expression of sphincteric action at the uterotubal junction.

Morphologically this phenomenon consists of the following: In the roentgenogram following its filling with contrast fluid, the normal uterine cavity ordinarily appears as a triangular or approximately triangular shadow. The apex of the triangle is directed downward, its base, upward. From the upper angles of this triangle arise the shadows representing the tubal canals, at first thread-like, then, farther out, of greater caliber. In a large dnumber of cases the continuity of the shadow near the origin of the tube at the uterine horn is either narrowed or completely interrupted (Fig. 1).

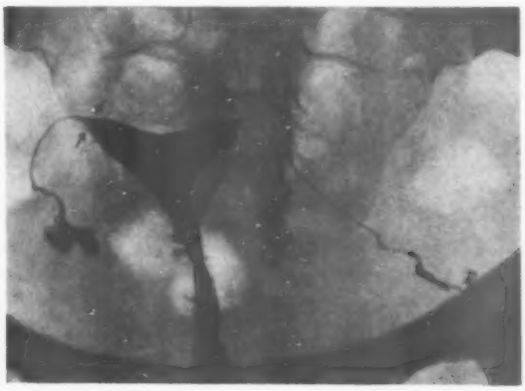


FIG. 1. Normal hysterosalpingogram with bilateral "sphincter" phenomenon.

FIG. 2. Diagrams of three types of the "sphincter" phenomenon.

When this phenomenon appears one can recognize three types among the great abundance of pictures which vary in detail (Fig. 2).

1. The continuity of the uterotubal shadow appears to be interrupted by a small shadow-free zone which seems to cut through the apex of the uterine horn obliquely. The portion of the shadow which continues laterally appears either in the form of a small equilateral triangle or of an elongated funnel with relatively distinct corners. Sometimes, by a rounding off of its base, it takes on a more club-shaped appearance.

2. The continuity of the uterotubal shadow is not interrupted. Nevertheless, the shadow at this point is characterized by a more or less definitely perceptible annular

* First International Congress of Radiology, London, July, 1925; 16. Kongress der Deutschen Röntgen-Gesellschaft, Wiesbaden, April, 1925.

† Bakke, Heuser, Reinberg and Arnstam.

constriction. Here, also, the shadow lateral to the constriction may appear in a variety of forms.

3. The third type is included here only for the sake of completeness. It is characterized by a second interruption of the shadow at the point at which the narrow thread-like portion of the tubal shadow begins. This second interruption of the shadow picture represents, in my opinion, a separate phenomenon and will be discussed later.

In the following we will designate the constriction phenomenon at the uterotubal angle as the "shadow narrowing phenomenon." The pictures of complete shadow interruption will also be included in this conception. Characteristic of the shadow narrowing phenomenon is the fact that it always appears at a typical point, namely at the transition of the uterine horn into the tubal shadow, sometimes unilaterally, sometimes bilaterally. It is further characteristic of the shadow narrowing phenomenon that lateral to it the thread-like tubal shadow does not begin immediately, but instead there is a somewhat wider portion of the shadow.

The morphology and the situation of the shadow narrowing phenomenon are so typical and suggest so strongly the conception of a ring-like constriction that all authors on first seeing this picture unanimously conceived it to be an expression of muscular contraction. In accordance with this conception, these authors, in discussion of this phenomenon, used either the definite designation "tubal sphincter," or the less definite term "sphincter-like muscular apparatus." Since these communications of sixteen years ago many articles of narrow scope as well as numerous comprehensive papers have appeared on the subject of hysterosalpingography in which the shadow narrowing phenomenon has been given adequate attention. The number of publications concerning this subject in the world literature may be several hundred. I know of no paper in which with more or less positiveness the terminology "sphincter of the tube," or "so-called sphincter," has not been used. Although today the shadow narrowing phenomenon is a familiar, everyday picture to all gynecologists who use hysterosalpingography, little or nothing has been done to investigate the anatomical basis of the phenomenon and its exact situation.

When we described the tubal sphincter in the roentgenogram in 1927, we could not find any confirmation in the literature for the assumption that there is in this region an anatomically demonstrable sphincter, namely a muscular apparatus which could be recognized within the circular muscular layer as a specific entity. We therefore believed rather that we might speak of a functional sphincter produced by special factors of innervation. We brought that appearance into analogy with the activity of the prepyloric portion of the stomach in which the peristaltic waves deepen to produce a complete circular constriction, without the presence of a demonstrable sphincter of the antrum (in contradistinction to the true pyloric sphincter). Bakke was not satisfied with the anatomical description then available and assigned Romcke to undertake new histological investigations of the portion of the tube and uterus involved. He reported on this matter as follows:

> By serial sections Romcke found a limited bundle of circular muscle fibres 2 mm. wide and 2 to 3 mm. thick, the position of which corresponds to the snare formation on the roentgen picture. The circular muscle fibres are situated quite close to the mucous membrane. Outside the circular bundle there are the usual cross-going fibres of the uterine musculature. The lumen corresponding to the circular bundle is lined with uterine mucous membrane and because of this the lumen will have to be considered as a part of the uterus. From that point of view the name "tubal sphincter" may be misleading but as its function undoubtedly is to close the passage through the tube, the name might just as well be retained. Roentgenologically, therefore, the existence of a sphincter has been clearly established and the finding has been verified by Romcke's anatomical investigations.

Since the above communication only two authors have undertaken the histological-anatomical investigation of this region with special reference to the question of the existence of a sphincter muscle. Sebastiani's investigation of serial sections of 12 uteri led to the following statement: "We cannot confirm

Romcke's findings concerning the existence of a special muscular sphincter apparatus, situated just outside the uterine orifice of the tube."

Ueno examined serial sections of the isthmus and the intramural portion of the tube of 10 uteri with special regard to the diameter of the tubal canal, the diameter of the circular muscular layers and the distribution of the nerve fibers. In no portion of the isthmus or of the intramural portion could he demonstrate a constriction. The diameter of the circular muscular layer of the intramural portion of the tube increases gradually, the nearer one approaches the opening of the tube into the uterine cavity. In no case did the circular musculature at a definite point become especially broad. The distribution of the nerve fibers which innervate the muscular fibers of the circular muscular layer at the junction between tube and uterus reveals no change in their density of arrangement. In no case was the distribution of the nerves especially well developed at any one locality. Ueno drew from his investigation the conclusion that no sphincteric apparatus, in the true sense of the word, can be recognized in the fallopian tube and that the sphincter phenomenon does not originate from the contraction of the tubal annular muscle itself but from the contraction of the uterine musculature.

Consequently, since we are able on the basis of these investigations to deny the existence of an anatomical sphincter at the tubal entrance, there remains completely unsolved the essential problem of the shadow narrowing phenomenon, namely the question of the nature of this manifestation. The interpretation of the phenomenon suggested by its appearance, that it is an expression of a circular contraction, has in no way been proved up to the present time. The second problem involved in the shadow narrowing phenomenon is the question of its situation. At which point of the uterotubal junction does this constriction actually appear? As one can recognize from the hysterosalpingograms, the phenomenon is situated in the neighborhood of, or immediately adjacent to the uterine orifice of the tube. However, a precise topography cannot be established merely by inspection of hysterosalpingograms. This depends primarily upon the difficulty of delimiting the intramural portion of the tube. In most cases the transition of the apex of the uterine horn into the tubal thread occurs in such a manner that the corner of the fundus gradually comes to a point and without visible demarcation continues into the thread-like tubal shadow. A delimitation of the intramural portion, suggested by the picture, is in these cases just as impossible as is the location of the shadow narrowing phenomenon. Reinberg and Arnstam assumed that the sphincter accurately indicated the opening of the tube into the uterus. We had the impression that the phenomenon was located medial to this point. Schultze, who justly stresses the difficulty of delimiting the intramural portion in hysterosalpingograms, believes that there exists at the apex of the tubal horn a rather broad zone in which a closing off of the uterus from the tubal lumen can occur. The decision as to whether such a constriction lies at the corner of the uterus or corresponds to the tubal ostium is somewhat arbitrary. Possibly, as Schultze believes, this uncertainty indicates that there is an area which functionally belongs to the tube as well as to the uterus.

Observations without anatomical confirmation are *a priori* dubious. My efforts to establish an anatomical basis for the shadow narrowing phenomenon have continued for many years. We thought that the solution of this problem could be approached by filling freshly extirpated uteri with contrast medium. When I again took up these experiments some time ago I remembered that I had obtained films by the contrast filling of the freshly extirpated uterus which made the shadow narrowing phenomenon recognizable with much greater distinctness than was the case with the uterus *in vivo*. These findings at first strengthened my assumption that we were dealing with a contraction phenomenon in the surviving uterus and we carried out the investigation in a larger number of uteri removed at operation about which we will report below.

Before we take up the technique and the

more detailed morphology of the hysterosalpingograms obtained, we shall discuss the advantages which the appearance of the shadow narrowing phenomenon in the extirpated organ seemed to offer for the study of the phenomenon. For this purpose a characteristic hysterosalpingogram is produced (Fig. 3).

Fig. 3. Hysterosalpingogram of the extirpated specimen.

Just as in the film of the living uterus filled with contrast substance we see also in the extirpated specimen the uterine cavity of approximately triangular configuration. From the two corners of the fundus arise the thread-like pictures of the tubal canal. Two to 3 mm. medial to the beginning of the tubal thread, the uterine apices appear definitely constricted and on one side at least may be demonstrated a complete hairline interruption of the shadow. The examination of specimens so obtained seemed to offer the following advantages over the hysterosalpingograms of the living uterus.

1. In addition to the shadow-producing filling of the cavity, the thickness of the uterine wall and its external contour are demonstrated.

2. The dimensions on the hysterosalpingograms correspond to the actual proportions of the specimens.

3. By picking out with radiopaque needles under the roentgenoscope the areas to be examined histologically, one is able to subject chosen portions of the specimen to an accurate topographical and anatomical examination.

4. The surviving organ is a very suitable subject for experimental studies under roentgenoscopic control.

The first and hitherto only author who has reported upon the occurrence of the shadow narrowing phenomenon in the extirpated organ is Butofsky in his paper "On the nature of the tubo-uterine sphincter." Butofsky, in a series of operatively removed uteri, demonstrated, after filling with contrast medium, the "sphincter phenomenon" in the hysterosalpingograms. Before I was acquainted with Butofsky's work I had been of the opinion that the shadow narrowing phenomenon, even in the surviving organ, was an expression of muscular contraction and that the organs to be examined must be kept alive as much as possible in order to produce the phenomenon. However, Butofsky demonstrated in interesting experiments that the constriction at the uterotubal angle definitely is not an expression of vital function. He showed that uteri placed in the ice-box as long as eight hours after removal from the body without any other care could maintain their contractility. But in order to be certain that he was dealing even after this period of time with muscular tissue incapable of reactivity, he paralyzed the smooth musculature in addition by submerging the uterus in a solution of chloral hydrate. With uteri four, six, and twelve days after their removal from the body, Butofsky was still able to obtain roentgenograms which showed the shadow narrowing phenomenon. The conclusions which Butofsky drew from these findings with reference to the nature of this manifestation cannot be accepted. The fact, says Butofsky, that these appearances may be seen in dead organs which have lost the power of contractility indicates that they are an expression of an anatomically preformed sphincter muscle. "Since the tubo-uterine sphincter, which we have shown on our roentgenograms, was obtained on the dead organs that were unable to contract and were functionally inactive, we must state that the sphincter is not a functional apparatus but an anatomical structure." These conclusions do not agree with the experiences derived from

roentgenograms of other hollow organs surrounded by smooth musculature. From these experiences one can conclude that the mere presence of a true sphincter muscle in the dead and therefore completely atonic condition can never cause such a marked constriction phenomenon in a shadow-producing cavity.

We examined 22 uteri which had been removed at operation from women varying in age between thirty-five and fifty-two years. Uteri distorted by extensive pathological changes were not used. At first I made efforts to bring the specimens under the roentgenoscope as rapidly as possible following their removal from the body. Later I made no special effort to do this and usually examined the specimen within an hour after operation. In a few cases, nevertheless, several hours had elapsed. As a contrast medium I first used lipiodol, later for reasons of economy, a suspension of barium sulphate in saturated gum acacia solution. The same apparatus for the injections was used as for ordinary hysterosalpingography, tightly fitted at the external os. The pressure which was used in the filling process was low (100–150 mm. Hg). In a few cases, however, for experimental reasons the pressure was elevated up to the limit of the capacity of the uterus. With constant careful observations of the filling process under the roentgenoscope, the contrast fluid was slowly injected until an outflow from the tubes occurred. At the roentgenoscopic observation it was possible, in most cases, to recognize whether or not a shadow narrowing phenomenon occurred. Usually, the roentgenogram, following the roentgenoscopic observation, revealed the presence of a shadow narrowing phenomenon, though of small degree, even in those cases in which the roentgenoscopic observation had been negative. An observation which seems to be extremely significant for further examinations may be mentioned here. In two specimens of the first group examined, there was seen under the roentgenoscope an apparently spontaneous moulding of the uterine content and a distinct spontaneous change in the contour of the uterine cavity, an unmistakable evidence of life in the extirpated organ. Of the 22 uteri one was that of a woman during the menopause, the others of menstruating women at various stages of the cycle. Two specimens were obtained during menstruation and one was a uterus bleeding as a consequence of tubal pregnancy. In all uteri a shadow narrowing phenomenon was recognizable. In a few cases, the phenomenon was but slight, faintest in the menstruating uteri and in the uterus of the tubal pregnancy case. In most cases the phenomenon was more or less distinctly visible, not always equally marked on the two sides. It was occasionally only unilateral. In the order of intensity of the shadow narrowing phenomenon four illustrations are shown which demonstrate the conditions better than any descriptions (Fig. 4–7).

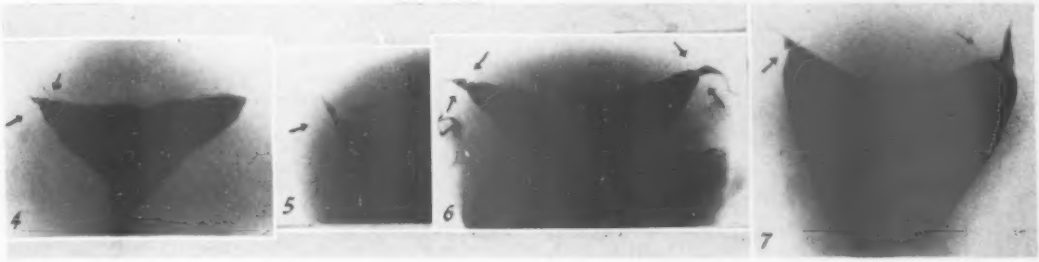


Fig. 4–7. Different degrees of the shadow narrowing phenomenon, Figure 4 shows a very slight degree of constriction. In Figure 5 there is a constriction of small degree. Distinct constriction is seen in Figure 6, and Figure 7 is typical of complete interruption of the shadow.

Everyone who is familiar with hystero-

salpingograms will recognize the complete similarity of the *in vivo* picture with those shown here. The same constriction, varying in degree up to complete interruption of its continuity, is present in both. There is the same apparently ring-like shape, the typical situation at the uterotubal angle and the typical appearance of the portion of the

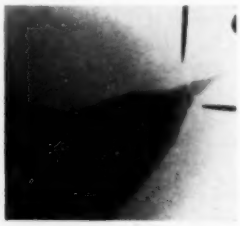


Fig. 8. Needles indicating the plane in which the shadow narrowing phenomenon lies.

shadow situated lateral to the shadow narrowing phenomenon which is interposed between the uterine cavity and the thread-like tubal lumen. Since, as already mentioned, these pictures are of practically the same dimensions as the anatomical specimen itself, and since the lateral margin of the intramural portion is rather distinctly recognizable at the exit of the tube from the uterine wall, a certain amount of information is available for the location of the shadow narrowing phenomenon. Since the length of the interstitial portion of the tube averages 1.5 cm., it can be stated as a result of comparative measurements of these hysterosalpingograms that the broader portion of the shadow lateral to the constriction belongs to the tube rather than to the uterine horn, so that the shadow narrowing phenomenon really appears to lie at the medial end of the interstitial portion of the tube. In order to subject this portion to an accurate histological examination, I attempted to determine the position of the shadow narrowing phenomenon by means of needles which were inserted under roentgenoscopic control into the uterine wall as close as possible to the lumen. After some practice I was able, with the aid of two needles, to mark fairly accurately the plane in which the constriction lay, and by drawing a silk thread through the tissue it was possible to keep this plane fixed even in the formalinized specimen (Fig. 8).

The histological examination showed that the markings correspond approximately to the point of transition between the mucous membrane of the body of the uterus and that of the tube, but showed

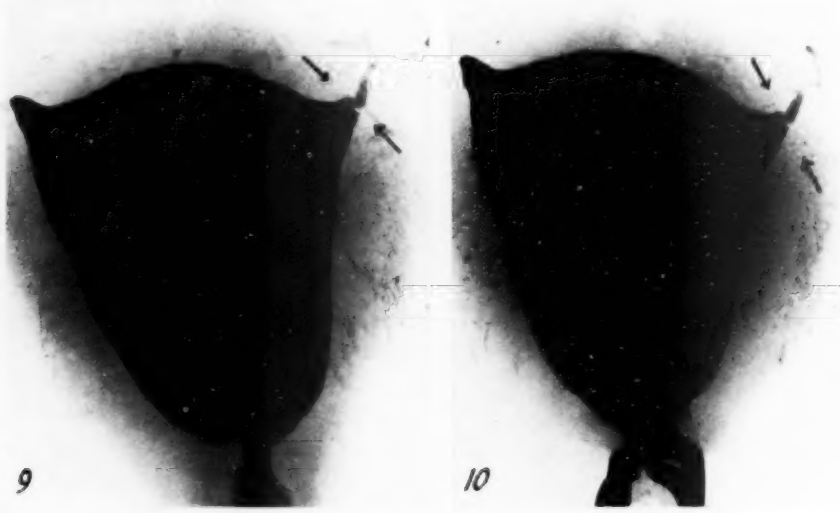


Fig. 9. Uterus before fixation. Anteroposterior projection.
Fig. 10. Uterus after fixation. Anteroposterior projection.

otherwise no variation from the familiar picture of the gradual transition of the uterine cavity into the tube. Therefore, this method failed to identify the anatomical basis for the shadow narrowing phenomenon and had to be replaced by another. Starting with the twelfth specimen

direction. Whereas in Figure 12 an evenly concentric shadow narrowing phenomenon is recognized, in Figure 11 the unilaterality of the point of constriction is demonstrable, as a result of which the connection between uterine horn and tube is distinctly seen to be eccentrically situated.

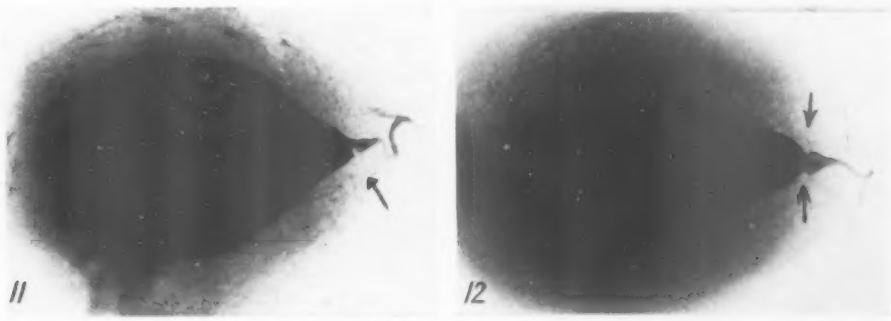


FIG. 11. Uterus after fixation. Caudocranial projection.
FIG. 12. Uterus after fixation. Caudocranial projection.

examined I developed the method which will be described. If the filling of the uterus under the roentgenoscope and the subsequent roentgenogram demonstrated the presence of a distinct shadow narrowing phenomenon, the tube and the cervix were clamped so that contrast fluid could not escape and the intrauterine pressure would be maintained. The specimen so distended was then fixed in formalin solution. Another roentgenogram was then taken. These roentgenograms showed the uterine cavity to have in all details the same shape found in the specimen prior to fixation. The morphology of the specimen was maintained and it was suitable for anatomical-histological examination (Fig. 9–12).

Figures 9 and 10 were taken before and after formalin fixation. The pictures do not differ in appearance. Furthermore, in the fixed specimen new details of the shadow narrowing phenomenon could be ascertained by a change in the direction in which the roentgenogram was taken. Figure 11 shows the uterotubal junction of the same specimen as in Figure 9 and Figure 10 taken in craniocaudal direction. Figure 12 shows a second specimen taken in the same

If the dilated uterine cavity of the hardened specimen is opened by cutting off the uterine horn a picture such as the following presents itself (Fig. 13): One sees the oval cross-section of the dilated uterine horn which does not show on its lateral wall a funnel-shaped transition into the tube but rather a wall which seems evenly rounded

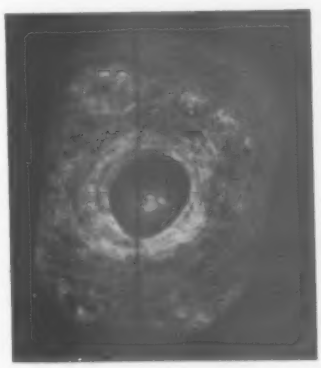


FIG. 13. View into the horn of the hardened uterus; natural size.

off. A small circular opening is recognizable at the apex of the convexity. The size of the opening is different in each specimen. In cases with well marked shadow narrow-

ing phenomenon it varies from the size of a needle point up to approximately 2 mm. in diameter. In cases with less distinct shadow narrowing phenomenon, the partition between corpus and tube is reduced to a circular or semilunar fold which permits a view into a funnel-shaped, narrow area beyond. In cases in which the roentgenograms show only a suggestion of a constriction, one finds, correspondingly, in the anatomical specimen only a circular or

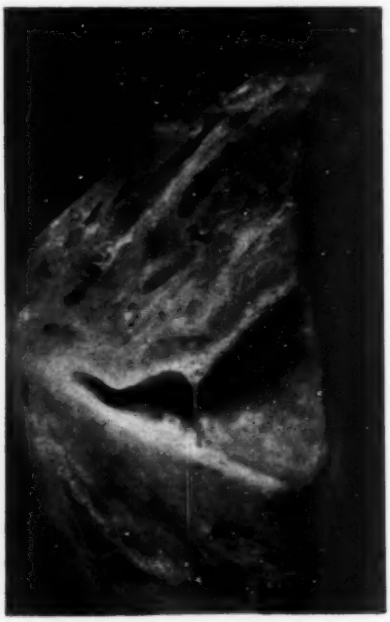


Fig. 14. Frontal section through the uterotubal horn. 3× enlarged.

sickle-shaped projection of the uterine wall bulging into the lumen. The frontal section through the uterotubal horn (Fig. 14) shows, even grossly, that the diaphragm-like partition between corpus and tube is formed entirely of mucous membrane. In the roentgenogram the line of demarcation between muscular wall and mucous membrane can be traced distinctly and inspection shows that the musculature plays no part in the formation of this barrier between tube and uterine cavity. The histological picture of this section (Fig. 15) shows that the uterine cavity is lined by a thick mucous membrane of premenstrual type. At the tubal orifice the mucous membrane is elevated both at the fundal wall and at the lateral wall into a fold-like projection which represents the anatomical basis for the shadow constriction seen in the hysterosalpingograms. The findings in 7 histologically examined uterotubal regions agree essentially and will later be discussed in detail.

On the basis of these findings the problem of the shadow narrowing phenomenon appears to be solved. The question concerning the nature of the phenomenon may now be answered. It is produced by a folding of the mucous membrane of the corpus. Its situation is established at the boundary between uterine cavity and the tube. The problem as to where the portion of the shadow lateral to the constriction phenomenon belongs is anatomically clarified by the identification of this part as a dilated portion of the pars intramuralis of the tube.

Two objections may be raised at this point which, in my opinion, merit discussion. First, are the results of the examination of the lifeless extirpated uterus valid in explaining the findings obtained by hysterosalpingography of the living uterus? Are both manifestations produced by the same causes? Is the shadow narrowing phenomenon of the living uterus a manifestation different from that demonstrated

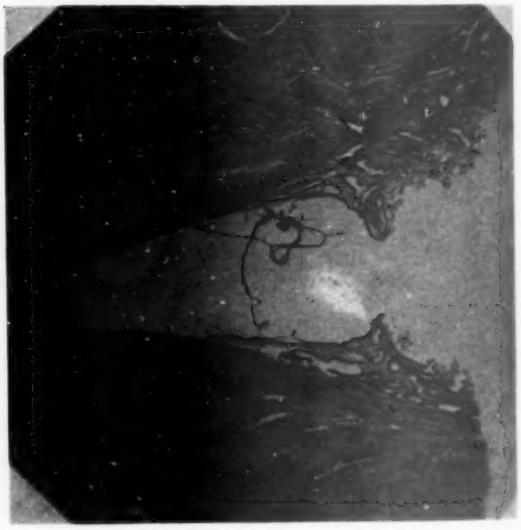


Fig. 15. Photomicrograph of frontal section through the uterotubal horn.

on the dead organ? We feel justified in assuming that the manifestations in the living uterus are based upon the same factors which we have demonstrated in the dead organ.

The morphology of the shadow narrowing phenomenon observed in the filling of the uterus *in vivo* looks the same, in all details, as that of the extirpated uterus. In view of the similarity of the roentgenograms, it would hardly be logical to assume two different underlying causes. Second, in 2 of the 22 uteri examined, contractions were observed under the roentgenoscope with the same impressive distinctness which have been observed in the uterus in the living body. This phenomenon has previously been described and illustrated by us in serial roentgenograms. After deposition of the contrast medium into the uterine cavity the molding of the substance within the uterus and the filling of the tube were left to the spontaneous contraction of the uterus. The occurrence of the shadow narrowing phenomenon in these two surviving uteri, its observation under the roentgenoscope and its demonstration in the roentgenogram, which conform with the pictures of the other specimens, likewise argue for the identity of the phenomenon in the living and dead uterus. Finally, there is still another detail of the picture which has long caused me to doubt that the phenomenon is an expression of muscular contraction. If one looks at the shadow constriction of the living uterus under the magnifying glass one finds in many cases of incomplete narrowing that the narrow area is formed of two pointed wedges directed toward each other. In cases of narrowings in the roentgen shadows of hollow muscular organs caused by muscular contraction, the projections at the point of contraction are not sharp but rather rounded off toward each other. This is occasionally seen in the narrowing at the internal os of the cervix uteri where there is a true anatomical sphincter.

A second objection might be raised against the value of the results of these examinations. What conclusions can we draw from these findings observed in lifeless organs? Are we not dealing with artefacts which are produced by artificial manipulations and which permit no analogy to the processes in living organs? This objection is in part invalidated by the facts above mentioned. In addition, one may point out that the same causes which are capable of producing these manifestations in dead organs are artificially called into play also in the living uterus. Also the filling with contrast material and the insufflation of the living uterus are unnatural operations. Here, too, the uterine cavity after closing off of its orifice is put under pressure with fluid or gas. And the occurrence of mucosal folds at the tubal entrance is unquestionably a result of pressure forces. Now, we may observe the shadow narrowing phenomenon in the living uterus even in those cases in which the contrast material is deposited into the cavity of the uterus without any particular vis a tergo and the uterine orifice is not instrumentally occluded. Also in these so-called spontaneous fillings of the tubal lumen with contrast oil, it is pressure forces which fill up at least the beginning portion of the tube. The pressure is called forth by the contraction of the uterine muscle which seeks to empty itself of its contents. A very tight closure of the cervical canal in conjunction with the intense contractions of the uterine horn causes pressures which basically affect the mucous membrane in the same manner as does the filling with an injection syringe. By means of the fixation of the specimen in formalin, with maintenance of its filling pressure, the otherwise transitory status of the pressure and elasticity conditions of the mucous membrane and muscle wall are permanently fixed.

We consequently arrive at the conclusion that the occurrence of mucosal folds and the dilatation of the tube under pressure in the dead organ must be considered equivalent in a large measure to the processes which occur with the filling of the living uterus.

For the occurrence of the mucosal folds two prerequisites seem important: (1) the dilatation of the uterine cavity and some pressure upon the mucous membrane; (2) a certain degree of thickness of the mucous membrane. The degree of distention of the uterine wall and the height of the pressure within the uterine cavity are dependent upon the capacity of the cavity and the quantity of the injected fluid. Avoiding discussion of the complicated analysis of the elasticity and pressure factors which the uterine cavity, it becomes obvious at once that the pressure within the filled uterus does not exceed a limit of small

degree, as long as the injected medium is not sufficient to unfold the cavity completely. Even at this stage of filling we observed in the roentgenogram the occurrence of fold formation.

It is thereby proved that, in general, even very low pressures suffice to produce fold formation. Conversely, on the other hand, we observed that it was not possible to cause a disappearance of folds, once formed, by means of pressure, however great.

Concerning the dependence of fold formation upon the thickness of the mucous membrane and consequently of the phase of menstruation, the following observations were made: Only a moderate amount of constriction was demonstrable by roentgenography in two uteri removed during menstruation (on the third and fourth day respectively after the beginning of bleeding). As early as one week after menstruation distinct fold formation appeared in uteri. Uteri in the second to the fourth week after menstruation usually manifested clear fold formation. Nevertheless, no regular relationship was established in the sense that with the approach of menstruation the fold formation increased. One uterus which showed particularly marked fold formation had been removed one day before menstruation. On the other hand, there was one uterus, likewise premenstrual, with only very poor fold formation. There are certain differences between reaction of the mucous membrane in living and dead organs. We may assume that in the living the mucous membrane with its filled lymph and blood vessels and its consequently increased turgor presents a greater resistance to pressure.

These roentgen observations in conjunction with anatomical examination of the distended uteri are of special value in clarifying the relationships of the intramural portion of the tube. The intramural portion occupies a position in the genital tract which is extraordinary in some respects and because of which it has been the subject of intensive studies. As far as we could find from the literature, nevertheless, anatomical examinations of artificially distended uterine cavities, with special regard to the tubal entrance, have not previously been carried out, although this method has been used with success for the study of other hollow organs, for example, the distention and hardening of the cecum for the study of the ileocecal valves.

Of the authors who in recent years have studied the interstitial portion of the tube, Hermstein and Neustadt, Geist and Goldberger, Daniel, Sebastiani, Ueno and Schröder may especially be mentioned. According to these authors, the morphology of the interstitial portion in the formalin fixed uterus may be described as follows:

The interstitial portion, averaging 1.5 cm. in length, represents the junction of the free tube with the uterine cavity and pursues a varied course. In about half of the cases it is a canal which is straight or is slightly convexly bent upward, and in the remaining half it proceeds with the formation of convolutions and kinkings through the wall of the uterus. The narrowest portion of the tube lies at the junction with the isthmus (Ueno), and quite gradually dilates from this point toward its uterine end. The lumen of the intramural portion measures on the average 0.5 to 1.0 mm. Macroscopically a sharp demarcation of the tube from the uterine horn is not demonstrable. The opening of the tube into the uterine cavity results in a gradual enlargement of the lumen in the form of an isosceles triangle with its base opened toward the corporal cavity. The lateral portion of this interstitial part of the tube is relatively rich in folds (in cross section four or five). These folds differ from the folds of the rest of the tubal mucous membrane in that in most cases they do not branch so richly and are not so slender. They are simple and broad. Toward the uterine end the folds become lower and gradually pass medially into small bud-like elevations. These, too, become very infrequent and in some cases disappear completely at the uterine end of the intramural portion. The mucous membrane consists here, as a rule, of a single layer of cylindrical epithelium and a thin scanty tunica propria. This 2 to 3 mm. wide area which is distinguished from the remaining tubal mucosa by the absence of typical tubal folds and an especially scant tunica propria is designated by Hermstein and Neustadt as transitional zone. This abruptly changes into the mucous membrane of the corpus which is characterized by the occurrence of glands and cytogenous stroma. This zone of

flat corpus mucous membrane does not have all the characteristics of the normal thick endometrium, but is differentiated from the latter by the smaller number of glands, its more irregular outline, more closely grouped glands, less cellular stroma and a scanty tunica propria (Geist and Goldberger). To the characteristics of this narrow portion of the corporal mucous membrane mentioned by Geist and Goldberger, I wish to add two others. According to my own observations the glands in this area do not seem to be subjected in the same way to the cyclic changes as those in the remaining endometrium, and according to the findings of H. R. Schmidt, even in cases of advanced pregnancies the stroma in this region only exceptionally shows decidual reaction. This zone of the corpus mucosa is designated by Geist and Goldberger as transitional zone. We, therefore, have here an area which is lined by two different kinds of transitional mucous membrane.

In contrast to the remaining portions of the tube, there lies in the intramural portion, immediately adjacent to the mucous membrane, a layer of muscle fibers which pursues a preponderantly longitudinal course, being separated from the mucosa only by the narrow fiber strains of the tunica propria. This layer is rich in connective tissue and extends laterally up to the pars isthmica where it completely disappears. It is well developed in its lateral portion, about 100 microns thick (Schröder), less well developed in its medial portion where, however, it also completely encircles the mucous membrane. Farther medially this layer

Fig. 16. Distinct anatomical uterine orifice of the tube at the right side.

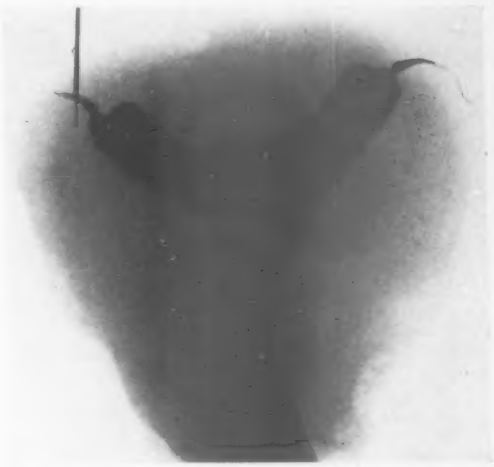


Fig. 17. Distinct anatomical uterine orifice of the tube bilaterally, marked by abrupt enlargement of the lumen.

loses itself in the musculature of the corpus. Daniel emphasizes, particularly, the abundance of connective tissue in this inner muscular layer, connective tissue being present in this proportion neither in the free tube nor in the wall of the uterus. Peripheral to the longitudinal layer lies a circular muscular layer which is in general somewhat looser because the connective tissue meshes in which its fibers lie are somewhat broader. The thickness of this layer amounts to 200 or 300 microns (Schröder). Closer to the uterus this layer increases in breadth and loses itself in the stratum vasculare of the uterus.

The transition of the pars intramuralis into the uterus is rich in variants as one so often sees at the borderline between mucous membranes of different structures. These variants may involve the transition of the tubal canal into the uterine horn as well as the transition of the two mucous membranes (Hermstein). For instance Hermstein finds that in a few specimens the transition of the tubal canal is characterized by a certain angulation which may be considered as a point of demarcation. Hermstein, as well as Geist and Goldberger, found occasional exceptions to the previously described gradual transition of the two mucous membranes. In these exceptional cases there was an extension of the mucosal folds of the tube down to the uterine orifice, passing abruptly into the gland-containing mucosa of the corpus. (Hermstein found this twice in 15 cases.)

From the above descriptions it follows

that there is no macroscopically recognizable abrupt enlargement of the lumen at the uterine entrance of the tube which could be called an anatomical orifice, but that we are well able to distinguish the boundary between corpus and tube on the basis of

Fig. 18. Frontal section through the uterotubal horn, 3× enlarged, showing angulation between fundal and tubal wall.

the structure of the mucous membrane (histological orifice). These conditions appear changed in the distended uterine specimens. Disregarding the fact that the constriction in the roentgen shadow indicates the boundary between tube and corpus, we find in the majority of roentgenograms that the contour lines of the fundal and lateral wall of the uterus follow a course that is almost straight and passes without noticeable kinking into the contour line of the dilated portion of the tube. From this, the dilated portion of the tube appears to be a direct continuation of the shadow of the uterine horn, a portion of the cavity of the corpus. In only 2 of the 22 uteri can we accurately determine by inspection of the roentgenogram alone the boundary between tube and uterine cavity (Fig. 16 and 17). Figure 16 shows, on the right, the only tube among the many specimens which could not be dilated. Figure 17 shows the tubes which open into the broad, rounded uterine horns and are only slightly distended. In both specimens, the transition of the tubal canal into the uterine cavity is abrupt. The wall of the fundus and the lateral wall of the uterine cavity form approximately a right angle with the wall of the tube. Inspecting these roentgenograms, it may be claimed unreservedly that here a distinct anatomical orifice is present. Such an orifice, however, was recognizable in the majority of the distended and subsequently fixed uteri if cut frontally through the uterotubal junction (Fig. 18).

Figure 18 shows how the walls of the fundus and of the tube form an almost right angle with each other. In 7 specimens examined with reference to this point, an angulation of this kind, more or less marked, could be observed. In most cases it was only to be recognized on one wall, occasionally on both walls. One gains the

Fig. 19. Enlarged roentgenogram of a stage in the filling process at the uterotubal angle.

impression that through the dilatation the anatomical architecture peculiar to the uterine cavity is brought out more distinctly and distinguishes itself recognizably from the structure characteristic of the tube. The uterine horn is enlarged in an almost spherical form, while the tube is

distended into the form of a funnel. The distention of the tube results not at all, or in only small measure, from pressure of the fluid penetrating into the tube, but is rather a consequence of the distention of the uterine wall. The tube is drawn apart rather than pushed apart. This may be clearly recognized from an enlarged view of the filling process at the uterotubal angle (Fig. 19). Here is seen the completely filled uterine horn from which the contrast medium passes through the narrow connecting channel into the dilated lumen of the tube. This dilatation occurs simultaneously with the dilatation of the uterine cavity and appears in the roentgenogram not yet completely filled by the contrast fluid. Schematically the changes at the uterotubal angle may be demonstrated in the following manner (Fig. 20):

It is tempting to explain this previously undescribed distensibility of this portion of the tube on the basis of the anatomical structure. As explained above, the intramural portion of the tube possesses an internal layer of longitudinal muscle which is rich in connective tissue. This layer in conjunction with the looser circular layer insures the pars interstitialis of an almost complete independence while piercing the muscular wall of the uterus (as is the case with the ureter piercing the bladder wall). The intramural portion is not influenced by the changes in tension of the uterine wall to which it is capable of offering strong resistance because of the firm connective tissue of the longitudinal muscular coat. At the most medial portion of the pars intramuralis, however, the

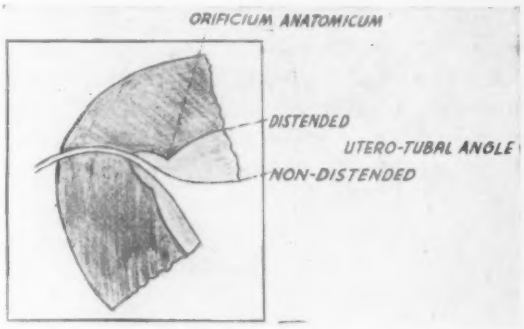
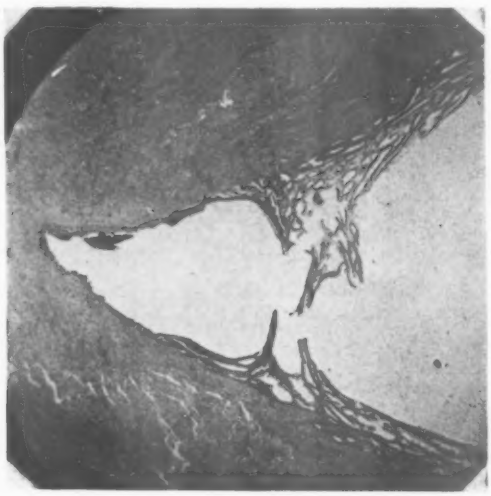


Fig. 20. Schematic drawing of the tubo-uterine transition in distended and non-distended specimen (muscular wall only).

longitudinal muscular layer diminishes somewhat in thickness and therefore reduces the independence of the tube. Moreover, both muscular layers of the tube are here more closely connected to the uterine wall by their transition into its muculature, and therefore more subject to the changes in the tension of the uterine wall.

The inner contour of the uterotubal junction in the distended specimen is deter-



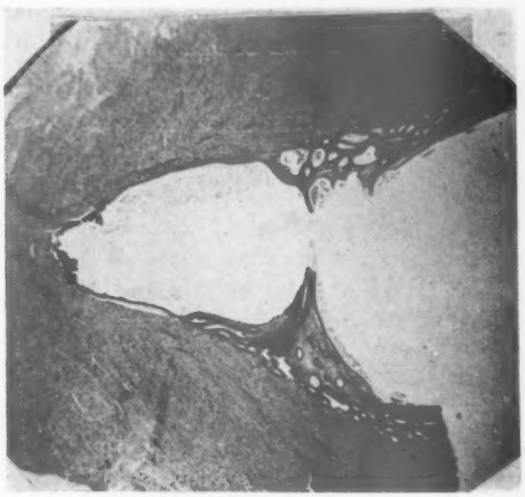


Fig. 21. Diaphragm-like fold formation. Mucosa in premenstrual stage.
Fig. 22. Diaphragm-like fold formation. Mucosa in interval stage.

mined largely by the behavior of the mucosa. In the frontal section of 2 specimens with distinct diaphragm-like fold formation one can see the mucous membrane as a crest-like protrusion within the lumen (Fig. 21 and 22). These folds, formed entirely of corporal mucous membrane, terminate at their summit in one or two pointed peaks. Since the folds form the transition from the mucous membrane which is thick and rich in stroma into the tubal mucosa which is almost completely free of stroma consisting

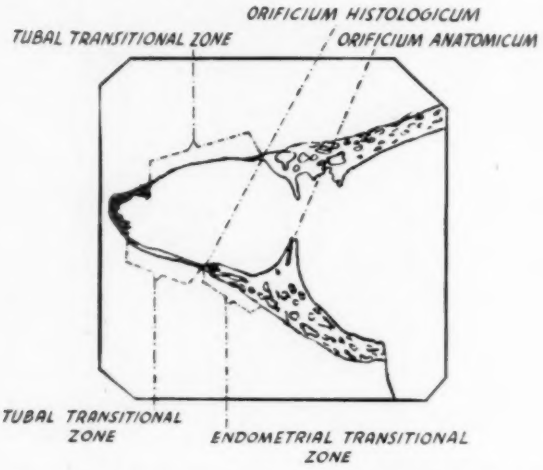


Fig. 23. Showing the position of the histological and anatomical orifice and of both different transitional zones of the mucosa.

of one row of epithelium, one usually finds that the mucosal depression toward the uterine cavity is flatter than that toward the tube. Here the mucous membrane either falls away steeply toward the muscular wall and passes almost directly into the tubal epithelium which covers the muscular wall or the lateral descent from the fold appears less steep in the form of a more rounded depression. In the latter case there is no immediate transition into the tubal mucosa at the base of the fold, but rather the corporal mucosa pushes itself into the tubal entrance with a gradual flattening and considerable loss of thickness. In this area we are unquestionably dealing with that corporal mucosa which Geist and Goldberger designated as transitional zone. Laterally, adjacent to this area, we again find the single-layered tubal epithelium which lines the greater part of this dilated portion of the tube. At the point at which the tube narrows to its normal width, one begins to see the first elevations of the tubal mucous membrane in the form of small bud-like prominences. The tunica propria begins to develop more abundantly. The further course of the tube cannot be seen in these views, since it is situated at another plane. The portion of the tubal mucous membrane from the margin of the gland-containing corporal mucous membrane up to the point where the tube is not dilated represents that zone of 2 to 3 mm. length which Hermstein and Neustadt have designated as indifferent transitional zone. In those specimens in which there is an angulation between the wall of the uterine cavity and that of the tube, an anatomical orifice is demonstrable. One finds that the mucosal fold is in direct continuation with this angulation point or in its immediate neighborhood at the entrance of the tube. If we bear in mind that the boundary between corporal and tubal mucosa is determined by the transition between gland-containing and gland-free mucous membrane, we find the histological orifice of the tube within the dilated portion lateral to the fold (Fig. 23).

This part of the pars intramuralis immediately adjacent to the uterine cavity is worthy of designation by a special name. A large part of these peculiarities are present in the resting uterus in a latent form and appear only in the filled or insufflated uterus. In 1885, Bayer described in two gravid uteri a cup-like enlargement of the uterine end of the tube and its inclusion into the fetal sac containing cavity. He designated this part in analogy with the lower uterine segment by the name "tubal segment" and understood by this term that upper portion of the cavity of the pregnant uterus which owes its formation to the distention of the tube. Investigations by H. R. Schmidt of a larger number of pregnant uteri confirm the fact that after the third month of pregnancy the uterine entrance of the tube enlarges and may at-

tain a diameter of 10 to 15 mm. The designation "tubal segment" is logical only in its application to the pregnant uterus and indicates that it belongs to the uterine cavity as a segment of tubal origin. In accordance with the result of these present investigations, one is justified in speaking of a bulbus or an antrum tubae into which this transitional part of the tube transforms itself under certain circumstances. The name "bulbus" would be used in a purely descriptive sense. The designation "antrum" would seem more logical from the anatomical point of view and, from the functional point of view, in accordance with the concept of a current directed from the uterus toward the abdominal cavity.

The antrum tubae would represent that medial portion of the pars intramuralis which, characterized by its distensibility, is delimited medially by the above-described fold formation, and laterally by that point of the tube which is not distensible. It is lined, for the most part, by a mucous membrane consisting of one layer of cylindrical epithelium and a sparse tunica propria (transitional zone according to Hermstein). To a small extent, it is lined by a corporal mucous membrane, characterized by a smaller number of glands, relatively sparse interglandular tissue and by the lack of reactivity to hormonal impulses (transitional zone according to Geist and Goldberger). In roentgenograms, we see in the antrum tubae, a well-defined section which allows us to interpret with more precision our hysterosalpingographic findings.*

The distensibility of this junction between the dilatable uterus and the nondilatable tube and its diaphragm-like separation from the corporal cavity may offer a hint of a special functional significance of the antrum tubae. We would like to avoid speculative discussions concerning the physiology of this area; I do wish, however, to point out that much valuable knowledge has been gained by the analysis of the contraction processes of the uterus and tube observed by serial roentgenograms. We draw attention to those which show feeler-like and bud-like protrusion of the contrast medium from the uterus into the tube, to the increased contractility of the uterotubal horn and to the unilateral independence of the uterine horn contractions. Observations of the filling process of the uterus *in vivo* by means of roentgenograms are necessarily restricted and are difficult to place on an experimental basis. However, by the study of the filling processes of the artificially surviving uterus under roentgenoscopic control and serial roentgenograms, it may be expected that additional information will be gained for the solution of functional and pharmacological problems.

* At this point, we will, in brief, refer again to a statement made at the beginning. In Figure 2 we find within a schematic reproduction of the pars intramuralis in the hysterosalpingograms of the living uterus the type three which is distinguished from the preceding types by a second interruption of the shadow lateral to the preceding one. This interruption is situated exactly at the point where the antrum tubae passes into the normal, narrow part of the pars intramuralis. The reason for its occurrence may be found in the changes of the flow at this transitional point between the broad and narrow part of the canal, and in the appearance of the first small mucosal folds of the tube.

SUMMARY

1. In twenty-two operatively removed uteri the occurrence of a "tubal sphincter" or shadow narrowing phenomenon has been demonstrated.

2. For various reasons, above all because of a complete morphologic agreement with the roentgenograms obtained from the living uterus, the anatomical conditions which form the basis of these views in the dead uterus were considered identical with those in the living uterus.

3. The anatomical basis and topography of the shadow narrowing phenomenon has been discussed. It has been shown that it is not a sphincteric contraction or a muscular contraction at all, but rather a fold formation of the mucous membrane of the corpus at the transition between corpus and tube. Consequently, the portion of the shadow situated lateral to the shadow narrowing phenomenon, the identity of which was previously problematical, has been recognized as belonging anatomically to the pars intramuralis.

4. On the basis of the anatomy and histology of the dilated portion of the tube, it is possible to delimit this section from the remaining portions, justifying its designation as antrum tubae.

5. For the examination of functional processes at the uterotubal transitional area a method of investigation is proposed which consists of a combination of filling with a contrast medium of the artificially surviving uterus, roentgenoscopic observation and the taking of serial hysterosalpingograms.

I wish to express my sincere thanks to Dr. Henry C. Falk, to whom I am deeply indebted for his kind interest and generous support.

REFERENCES

1. Bakke, S. N. Vorlaufige Mitteilung über Uterosalpingographie. *Acta obst. et gynaec. Scandinav.*, 1927, *6*, 161–166.
2. Bayer, A. Morphologie der Gebärmutter. Freund, Gynäkol. Klin., 1885.
3. Butofsky, M. K. On the nature of the tubouterine sphincter; experimental study. Am. J. Roentgenol. & Rad. Therapy, 1933, *29*, 469–478.
4. Daniel, C. Etude sur la trompe interstitielle normale. *Gynéc. et obstét.*, 1926, *13*, 1–18.
5. Geist, S. H., and Goldberger, M. A. Study of intramural portion of normal and diseased tubes, with special reference to the question of sterility. *Surg., Gynec. & Obst.*, 1925, *41*, 646–654.
6. Hermstein, A., and Neustadt, B. Intramural portion of the tube. *Ztschr. f. Geburtsh. u. Gynäk.*, 1924, *88*, 43–60.
7. Heuser, C. Metrosalpingorradiographia. *Semana méd.*, 1926, *2*, 1667–1671.
8. Reinberg, S. A., and Arnstam, O. I. Metrosalpingographische Röntgenstudien über die Anatomie und Physiologie der Uterushöhle und der Eileiter. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1926, *35*, 54–64.
9. Schneider, P., and Eisler, F. Hysterosalpingographie. *Wien. klin. Wchnschr.*, 1926, *44*, 1290.
10. Schneider, P., and Eisler, F. Gibt es einen Tubensphinkter? Sphinkterbildungen am Uterus? *Zentralbl. f. Gynäk.*, 1927, *51*, 23–30.
11. Schneider, P., and Eisler, F. Hysterosalpingographie. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, *35*, 1007–1034.
12. Schmidt, H. R. Das Verhalten des interstitiellen Tubenabschnittes inbesondere des uterinen Tubenostiums in der Schwangerschaft. *Ztschr. f. Geburtsh. u. Gynäk.*, 1923, *86*, 459–481.
13. Schröder, R. Handbuch der mikroskopischen Anatomie des Menschen. Weibliche Genitalorgane. Bd. VII/1, 404–406.
14. Schultze, G. K. F. Gynäkologische Röntgendiagnostik. F. Enke, Stuttgart, 1939.
15. Sebastiani, E. Ricerche istologische sulla struttura del tratto interstiziale della tromba in rapporto con l'esistenza di uno sfintere utero-tubarico. *Folia gynaec.*, 1933, *30*, 647–657.
16. Ueno, J. Study on so-called "sphincterial apparatus of fallopian tube." *Jap. J. Obst. & Gynec.*, 1933, *16*, 562–569.

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Twenty-eighth Annual Meeting: 1943, to be announced.

EDITORIAL

THE ANNUAL MEETING

THE Forty-third Annual Meeting of the American Roentgen Ray Society held in Chicago on September 15 to 18, 1942, proved to be one of the most interesting and profitable that the Society has held in a long time. When it was found that it would be necessary to transfer the meeting place from Atlantic City to Chicago there were some who had certain misgivings, such as whether there would be a good attendance and whether the commercial and scientific exhibitors would still be interested in the meeting, especially when they were given such short notice about its change. It soon became evident that not only the members of the Society but the exhibitors as well were interested in the meeting and the attendance, while not as large as the 1940 and 1941 meetings, was yet excellent, 558 members and guests being registered.

Dr. Bromer, the President-elect, in spite of the difficulties which he encountered in the arrangement of the program, need offer no apology for the program which he ultimately presented. Since these are war times, a great number of officers in uniform were present which gave the meeting a somewhat military air. The Society was particularly fortunate in securing for its guest speaker on the evening of the banquet Colonel Fred W. Rankin, who discussed "Radiology and Radiologists in the Present Emergency." He called attention to the needs of the armed services as regards its medical personnel and to the part that radiology must play in carrying its share of the load. He assured radiologists that they would be placed where they could carry on their specialty and where their specialized training would be of value.

On Wednesday evening occurred one of the annual events of the meeting, that of the Caldwell Lecture which was given this year by Dr. Cornelius Packard Rhoads, Director of the Memorial Hospital for the Treatment of Cancer and Allied Diseases of New York City. He chose as his topic "Newer Aspects of Cancer Research" and developed his subject in a most interesting manner detailing some of the very significant cancer research which is being carried out along chemical lines. At the close of the lecture President Bromer presented the Caldwell Medal to Dr. Rhoads.

The scientific exhibits were quite numerous and extensive and in their quality equaled the standard which has been set over the years. These were arranged by Dr. Archer and his committee who in spite of certain handicaps provided an exhibit which was extremely interesting and instructive.

The commercial exhibits also did not suffer in quantity or quality and as usual proved a valuable part of the meeting.

The Instruction Courses were well attended and as always were one of the interesting features of the meeting. The arrangement of the scientific program with all the papers being given in the morning, with an hour's recess at the midway point, and the instruction courses in the afternoon, gave ample opportunity for the members and guests to view not only the scientific but the commercial exhibits as well, and this arrangement of the program could profitably be followed at future meetings.

Owing to the war, the social activities which are usually held at the annual meeting were greatly restricted.

To the President-elect, Dr. Bromer, and the various committees which contributed to the success of the meeting, the Society desires to express its thanks. To the execu-

tive staff of the Palmer House the Society desires to express its appreciation for the splendid and capable manner in which all details in connection with the meeting were handled and for the many ways in which they contributed to the success of the meeting and to the comfort of the members and guests.

All of the activities of the Society and the splendid program which was arranged justifies the Executive Council in its decision to hold the annual meeting. The list of new officers as well as other detailed reports of the meeting will be found elsewhere in this issue.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

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United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, to be announced.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: 1943, to be announced.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

Arkansas Radiological Society
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Drake Hotel, Chicago, Ill., Nov. 30–Dec. 4, 1942.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology California Medical Association
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N.Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

Florida State Radiological Society
Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. L. W. Baird, Scott and White Clinic, Temple, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00-5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress.
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton Alberta.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

SCIENTIFIC EXHIBIT

The Scientific Exhibit at the Forty-third Annual Meeting of the American Roentgen Ray Society held in Chicago, Illinois, September 15 to 18, 1942, was in charge of Dr. Vincent W. Archer as Chairman, with Dr. Paul A. Bishop and Dr. S. W. Donaldson as the other members of the committee. Contrary to the earlier expectations and fears of Dr. Archer the exhibit which was finally assembled was equal in both quantity and quality to those at any of the preceding meetings. The space at the Palmer House in the exhibit hall was large and permitted of an attractive grouping and arrangement. With time given during a morning recess for viewing of the exhibits those in attendance found ample opportunity for the study which the exhibits deserved. A brief description of each exhibit follows.

GASTROINTESTINAL TRACT

In this section there were six exhibits, four of them very interesting ones from the University of Chicago. One was by Dr. Frederic E. Templeton, University of Chicago, Chicago, Illinois, on "Pharynx and Pharyngo-esophageal Junction." This was a demonstration of the normal pharyngo-esophageal region, including the use of the Valsalva test to bring out the cricopharyngeus muscle bundle; of abnormalities, including paralysis, atony, disordered functions of the cricopharyngeus muscle, Plummer-Vinson's syndrome, diverticula, with reference to etiology.

Dr. Herbert Lack, University of Chicago, Chicago, Illinois, presented the subject of "Congenital Hypertrophic Pyloric Stenosis: Roentgen-Ray Diagnosis and Effect of Surgery." This included a brief description of pathology, clinical signs, roentgen appearance of tumor in congenital hypertrophic pyloric stenosis before and after pyloroplasty. Also given were the technique of examination and appearance of the normal infant stomach.

An exhibit entitled " 'Curling' of Esophagus" was presented by Dr. Wendell P. Stampfli, University of Chicago, Chicago, Illinois. This took up the physiology of esophageal movements; technique of examination of esophagus; definition of "curling" of esophagus, with theories of etiology; presentation of pathologically proved cases, differential diagnosis. Also included were a description of esophageal movements including primary peristalsis, secondary peristalsis and local contractions with roentgenograms illustrating these various phases.

"The Phrenic Ampulla" was the subject of another exhibit from the University of Chicago by Dr. Gerhart Schwarz. The phrenic ampulla is a normal expansion of the lower end of the esophagus, described by older anatomists but overlooked in most modern textbooks of anatomy. It can be easily demonstrated by a special roentgen procedure, and is apt to be mistaken for congenital short esophagus. The exhibit consisted of films showing the technique of demonstration (after Reich); variations in appearance, and differentiation from diaphragmatic hernia.

"The Small Intestine in the Presence of the Hookworm" was the title of an exhibit by Major George R. Krause and Lieutenant James A. Crilly, Station Hospital, Fort Jackson, South Carolina. This consisted of a series of reproductions illustrating the various changes in the mucous membrane and the tunica muscularis of the small intestine due to the presence of the hookworm, *Nector americanus*. These changes are the same as those ascribed to the lack of various dietary factors, and described in the literature under the heading "deficiency pattern." The partial return towards the normal in many cases after antihelminthic therapy was illustrated. The fact that the changes illustrated here are the same as those described as "deficiency pattern" indicates that a uniform response occurs in the small intestine in response to a number of different causes. This exhibit was awarded Certificate of Merit, No. 5.

"Metastasis to Bone as the First Symptom of Gastrointestinal Carcinoma" was

the subject of an exhibit by Dr. E. J. Bertin, Misericordia Hospital, Philadelphia. The first three cases of gastrointestinal carcinoma were diagnosed from a biopsy made of the metastatic bone lesions before the development of any signs or symptoms referable to the gastrointestinal tract. In addition illustrations were given of some of the more or less usual lesions encountered in the average department of roentgenology.

SKELETON

Among the exhibits having to do with the skeleton was an interesting one entitled "The Roentgenological and Pathological Aspects of Ewing's Tumor" by Drs. A. Purdy Stout and Paul C. Swenson, Presbyterian Hospital and the College of Physicians and Surgeons, Columbia University, New York, N. Y. This consisted of a number of cases illustrating the protean aspects of the disease roentgenographically, as well as photomicrographic and gross pathological specimens of the various cases. This exhibit was awarded Certificate of Merit, No. 4.

Drs. L. W. Paul and E. A. Pohle, Department of Radiology, University of Wisconsin, Madison, Wisconsin, presented an exhibit entitled "Radiation Osteitis of the Ribs." Following roentgen irradiation to the chest wall after mastectomy for carcinoma of the breast, the authors have observed changes in the underlying ribs which appear to be due to radiation osteitis. The major manifestation of this process has been painless fractures of one or more (usually multiple) ribs. Non-union of these fractures has been the rule. The roentgen diagnostic aspects and the differential diagnosis, particularly with reference to metastatic involvement of the ribs, was stressed.

"Roentgenology of the Maxillofacial Bones" was the title of an exhibit presented by Lieutenant Colonel A. A. de Lorimier, Major Casper Epstein, and Major Joe C. Rude, Army Medical School, Washington, D. C. This was a demonstration of types of injuries and lesions which might complicate the analysis of these cases such as might be expected particularly in accidents incurred in Tank and Air Services. The exhibit included roentgenograms and drawings illustrating the technique of the examination, the frequency of the sites of the fractures and primary and metastatic tumors of the mandible. This exhibit was awarded Certificate of Merit, No. 3.

Dr. Lee A. Hadley, Syracuse, New York, had an exhibit entitled "Roentgenography of the Cervical Spine." This consisted of films demonstrating the normal lateral curve; traumatic angulation; flexion-extension studies; restriction cervical movement with follow-up; forty-five degree oblique views for intervertebral foramina; different types of constricted foramina; traumatic fusion of the spine compared with congenital fusion; spondylitis deformans; differentiation between basilar impression and atlanto-occipital fusion.

In the exhibit on "Osteoid Osteoma" by Drs. Maurice M. Pomeranz and William H. Merrit, Hospital for Joint Diseases, New York, were demonstrated lesions in numerous bones heretofore considered to be fairly typical of the sclerosing osteomyelitis of Garré. Dr. Henry L. Jaffe, pathologist at the Hospital for Joint Diseases has established that the bone alterations seen in the roentgenograms of this disease are produced by a benign bone tumor which he has termed an "osteoid osteoma." Illustrative cases, photographs and photomicrographs were shown.

Drs. John P. Stump and Ramsay Spillman, New York, presented an exhibit on "Roentgen Observations during Treatment of Club Feet." Dr. J. H. Kite has formulated certain simple mechanical principles which if followed lead to success, and which if ignored lead to failure, in the treatment of equinovarus. This exhibit, from patients treated by Dr. Stump following the Kite procedure, illustrated the principles and the steps in treatment.

"Degenerative and Pathologic Changes in Lumbosacral Intervertebral Discs" was

the title of an exhibit by Drs. R. K. Ghormley and M. B. Coventry, Mayo Clinic, Rochester, Minnesota. Degenerative and pathologic changes in lumbosacral intervertebral discs in various age groups were shown; also a series of selected roentgenograms and corresponding models in wax to bring out the significant feature of each roentgenogram. One enlarged model showed the anatomy of the intervertebral disc in detail.

"Correlation of Roentgenologic and Pathologic Characteristics of Skeletal Diseases" was the title of an exhibit by Dr. C. Howard Hatcher, University of Chicago, Chicago, Illinois. Translite prints of roentgenograms and photographs of gross specimens were shown. Large microscopic sections were utilized to demonstrate the characteristics of bone sarcoma, various types of arthritis and aseptic necrosis of bone. The exhibit was beautifully correlated and was most instructive.

GENITOURINARY

Drs. Karl Kornblum and Theodore R. Fetter, Jefferson Medical College, Philadelphia, presented an exhibit on "The Value of Excretory Urography in the Interpretation of Renal Function." In this investigation an attempt was made to determine the reliance which can be placed on the interpretation of renal function as revealed by excretory urography. Functional interpretations were made from routine excretory urograms and these compared with the results of the usual clinical tests employed in the determination of renal function. From the accumulated data certain definite conclusions regarding the value of excretory urography in the interpretation of renal function appear warranted.

"Roentgenological Evidence of Inhibition of Prostatic Cancer Metastases following Orchiectomy" was the title of an exhibit by Drs. Charles B. Huggins and William H. Thompson, University of Chicago, Chicago, Illinois. This included roentgenograms and protocols in 2 cases showing resolution of metastases and one case showing resolution and subsequent recurrence with a brief explanation of why orchiectomy produces resolution. There was also a presentation of unsuccessful cases with theory of why these cases were unsuccessful.

Drs. Howard I. Suby, Robina M. Suby, Fuller Albright and Hirsh Sulkowitch, Massachusetts General Hospital, Boston, presented an exhibit on "Dissolution of Renal Calculi." The exhibit consisted of four parts: (*a*) the development of "solution G"; (*b*) apparatus used for dissolving; (*c*) clinical cases, and (*d*) chemistry of stones from the roentgen appearance. The formula for solution G is as follows: 3.84 gm. magnesium oxide (anhydrous); 32.35 gm. citric acid; 4.37 gm. sodium carbonate (subhydrous); H_2O ad 1000 cc.; solution maybe autoclaved. The object is to keep the solution in contact with the stone as much as possible. The actual type of apparatus depends on the individual case and the ingenuity of the operator. Where the stones lie in the kidney calyces it is desirable that a slight amount of intrapelvic pressure be obtained to make sure that the solution gets around about the stones. However, the operator should see that this pressure is not continuous lest a constant back pressure stir up a pyelonephritis. The exhibit included many drawings of suggested type of apparatus that might be used and also roentgenograms of cases in which the method had been employed showing the stones before dissolution and roentgenograms following the disappearance of the stones under the use of the apparatus.

An exhibit entitled "The Petrous Pyramid of the Temporal Bone" was given by Dr. John R. Lindsay, University of Chicago Clinics, Chicago. This consisted of anatomical demonstration by means of drawings, and temporal bone sections showing the types of pneumatization of the pyramid; methods of demonstrating the pneumatized areas by roentgenography; pathologic exhibit showing the suppurative process in each type of temporal bone;

roentgenograms from clinical cases of suppuration in the pyramid illustrating each type of petrositis. The exhibit contained illustrations not only of the roentgen demonstration of the disease process but magnificent illustrations of the pathologic process, and included also the surgical classification of petrositis and a detailed demonstration of the roentgenological methods necessary in a study of the petrous apices. This exhibit was awarded Certificate of Merit, No. 2.

THORAX

Drs. Robert M. Daley, Harry E. Ungerleider, and Richard Gubner, Equitable Life Assurance Society of the United States, New York, presented an exhibit on "Evalution of Heart Size Measurements." Cardiac measurements are of greater value in recognizing enlargement of the heart as a whole rather than involvement of the individual chambers, which is best revealed by roentgenoscopic examination. Mensuration is unnecessary when gross enlargement exists but lesser degrees often escape detection on inspection and, conversely, an apparently large cardiac shadow may be normal when considered in relation to standards of body build. Innumerable measurements have been proposed and this has resulted in confusion and skepticism of all measurements. Various measurements were critically reviewed and it was shown that several, such as the cardiothoracic ratio, are without any value; whereas others, such as the heart volume, are of academic rather than practical clinical interest. A few simple measurements of proved value suffice for measurement of the heart size. These are the transverse diameter of the heart and of the aortic arch and the area of the frontal cardiac silhouette, in relation to predicted standards of weight and height. The frontal area can be accurately determined from the product $\pi/4$ long $\times$ broad diameters, the average deviation from areas determined planimetrically in 134 orthodiagrams being less than 3 per cent. A nomogram was presented indicating the actual area from the long and broad diameters and also the predicted area from weight and height, applicable both for the teleroentgenogram and orthodiagram. On the same chart was another nomogram for the predicted transverse diameter of the heart and also the predicted transverse diameter of the frontal aortic arch based on weight and height. When weight and height are not available, enlargement may be satisfactorily estimated in the roentgenogram by the relation of the lower left heart border to the left midclavicular line. This has long been a clinical criterion of enlargement, but may be applied even more accurately in the roentgenogram.

"The Thoracic Viscera: Tomographic Studies" was the subject of an exhibit by Dr. Carleton B. Peirce, Royal Victoria Hospital, Montreal, Canada. Previous papers by the author and his former associate, Stocking, have dealt with the correlation of anatomic and roentgenologic studies of cadaveric material with the shadows cast by the thoracic viscera on the roentgenogram and bronchogram. This exhibit developed further by tomograms the earlier studies of the intrathoracic structures, with particular reference to the mediastinum and the inconstant accessory pleural fissure on the left. This exhibit was awarded Certificate of Merit, No. 1.

An exhibit entitled "Planigraphic and Potter-Bucky Serial Studies of Cavity; with Devices to Limit Areas of Radiation and Economize Roentgen Film" was presented by Drs. F. Maurice McPhedran, Edwin L. Lame and Eleanor S. Cooper, Germantown Dispensary and Hospital, Philadelphia. In this a comparison was made of rectilinear laminagrams with posteroanterior and anteroposterior Potter-Bucky films of the chest. A lead diaphragm with adjustable aperture is used to protect the patient from excessive radiation in rectilinear laminagraphy by circumscribing the field of radiation. A lead screen is used to subdivide the standard sized roentgen film so that in serial studies detail views of several patients can be made on one 14 by

17 inch film. Subdivided films showed how critical areas, in cases under serial observation, may be defined with economy of film and without loss of accuracy.

TECHNIQUE

"Roentgenography of Soft Tissues by Monochromatic Roentgen Radiation" was the subject of an exhibit by J. de Carvajal-Forero, Ph.B., and Marvin R. Thompson, Ph.D., Warner Institute for Therapeutic Research, New York. In this, roentgenograms were shown demonstrating soft tissues in proportion to their different densities without sacrificing bone detail and density. Bony structures such as the pelvis, where the depth is not uniform, are brought out clearly with equal or almost equal density throughout and yet the soft tissue structures are clearly visualized. Early pregnancies, fibroids, placenta (in pregnancy) were shown. Complete differentiation of skin, subcutaneous tissue, muscular layers, tendinous attachments, vascular and pulmonary structures and bones is possible by this method. Pathologic conditions such as varicose veins, ruptured tendons, subcutaneous tumors, etc., can be demonstrated. The method includes "dark-room processing" in color forming developers where the amount of dye deposited on the emulsion is proportional to the oxidation of the silver at that point, thus giving slightly different colors to each structure. Visualization of roentgenograms through color filters emphasizes the desired contrast.

Dr. Russell H. Morgan, University of Chicago Clinics, Chicago, presented an exhibit on "The Exposure Meter in Roentgenography of the Chest." This consisted of a series of films showing the constancy of the average density of films taken with the exposure meter as compared with films whose exposures were determined according to methods generally in use today. A series of films exposed with the exposure meter and demonstrating the effect of variations in kilovoltage on the quality of roentgenograms of the chest was also shown. This exhibit was awarded the Bronze Medal.

A second exhibit by Dr. Russell H. Morgan, University of Chicago Clinics, was entitled "A Motor-Driven Potter-Bucky Grid Providing Continuous Motion." A motor-driven Potter-Bucky grid which moves continuously in a to and fro motion and at a constant speed across a film was shown. The device is entirely automatic in its operation and requires no cocking or other adjustments. A series of films demonstrating the quality of roentgenograms made with the instrument as compared with those made with the standard Potter-Bucky grid was also shown.

Another exhibit by Dr. Russell H. Morgan, University of Chicago Clinics, was on the subject of "An Exposure Meter for Use in Roentgenography." This included a small roentgenographic table with a built-in exposure meter. Phantoms of pressd-wood were used as subject material. A series of roentgenograms showing the quality of films exposed with the device was also included.

MISCELLANEOUS

Dr. Carl L. Gilles, Department of Radiology, State University of Iowa, Iowa City, Iowa, presented an exhibit on "Pseudo Gas Gangrene." It is not generally appreciated that some of the common aerobic bacteria such as *B. coli* and *B. proteus vulgaris* can produce gas in the soft tissues indistinguishable from gas gangrene. Five such cases were presented.

"Ionization Oscillograms" was the subject of an exhibit presented by Drs. Robert B. Taft, Charleston, South Carolina, and George C. Henny, Philadelphia. A single stage amplifier designed by one of the authors has sufficient sensitivity to take the ionization current from a thimble chamber and show its fluctuations on the screen of the cathode-ray oscilloscope. Photographs of the pattern are believed to be true time-intensity curves of the radiation output. Curves were shown on charts and the apparatus was in operation by a port-

able roentgen machine. A motion picture showed some of the patterns which were too unstable to permit demonstration by still photographs. This exhibit was awarded the Silver Medal.

Drs. T. C. Evans and H. Dabney Kerr, Department of Radiology, State University of Iowa, Iowa City, Iowa, presented an exhibit on "Experimental Modification of the Radiosensitivity of the Skin." This consisted of graphs and photographs illustrating the effects of low temperature and blocked circulation in reducing the radiosensitivity of the skin of the human and of mammalian experimental animals.

COMMERCIAL EXHIBIT

The Commercial Exhibit at the Forty-third Annual Meeting of the American Roentgen Ray Society held in Chicago, Illinois, September 15 to 18, 1942, was participated in by a large number of manufacturers. It is all the more appreciated this year both because of the uncertainty of the times and because a change in meeting place was necessary shortly before the meeting. The Palmer House has excellent facilities for exhibits and this together with the fact that the manufacturers themselves had taken unusual pains in furnishing attractive backgrounds for the display of their equipment made the exhibit an outstanding one. The following manufacturers were represented in the Commercial Exhibit: *Agfa Ansco*, Binghamtom, N. Y., *E. I. de Pont de Nemours and Company*, Wilmington, Delaware, *Eastman Kodak Company*, Rochester, N. Y. *Eureka X-Ray Tube Corporation*, Chicago, Ill., *E. Fougera and Company, Inc.*, New York, N. Y., *General Electric X-Ray Corporation*, Chicago, Ill., *Kelley-Koett Manufacturing Company, Inc.*, Covington, Kentucky, *Lea and Febiger*, Philadelphia, Pa., *Liebel-Flarsheim Company*, Cincinnati, Ohio, *Machlett Laboratories, Inc.*, Springdale, Conn., *F. Mattern Manufacturing Co.*, Chicago, Ill., *National Synthetics*, New York, N. Y., *Patterson Screen Company*, Towanda, Pa., *Philips Metalix Corporation*, New York, N. Y., *Picker X-Ray Corporation*, New York, N. Y., *Standard X-Ray Company*, Chicago, Ill., *Charles C Thomas*, Springfield, Ill., *Victoreen Instrument Company*, Cleveland, Ohio, *Westinghouse Electric and Manufacturing Company*, East Pittsburgh, Pa., *Winthrop Chemical Company, Inc.*, New York, N. Y.

NEW OFFICERS

At the recent meeting of the American Roentgen Ray Society held in Chicago, Illinois, September 15 to 18, 1942, the following officers were elected for the coming year: *President-Elect:* Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* Cornelius G. Dyke, New York, N. Y.; *2nd Vice-President:* Kenneth D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, Iowa City, Iowa (re-elected); *Treasurer:* J. Bennett Edwards, Leonia, N. J. (re-elected); *Member of the Executive Council:* J. C. Dickinson, Tampa, Florida. The *President* is Ralph S. Bromer, Bryn Mawr, Pa., and the *Chairman of the Executive Council* is Bernard P. Widmann, Philadelphia, Pa.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 105 Rutledge Ave.
Charleston, S. C.

A DEVICE TO AID IN POSITIONING FOR LATERAL ROENTGENOGRAMS OF THE FEMORAL NECK*

By M. T. KOVEN, M.D., BERNARD S. EPSTEIN, M.D.,
and MAX KULICK
BROOKLYN, NEW YORK

ROENTGENOGRAPHIC examination of the femoral neck in a true lateral projection is essential in the diagnosis and treatment of fractured femoral necks. Techniques have been devised in which the central ray is directed perpendicular to the femoral neck from above after the involved thigh has been partially flexed and externally rotated,[1] and an anglemeter has been made to aid in obtaining proper positions.[2] Other techniques direct the central ray perpendicular to the femoral neck by placing the roentgen tube between the patient's legs in the same plane as the extended

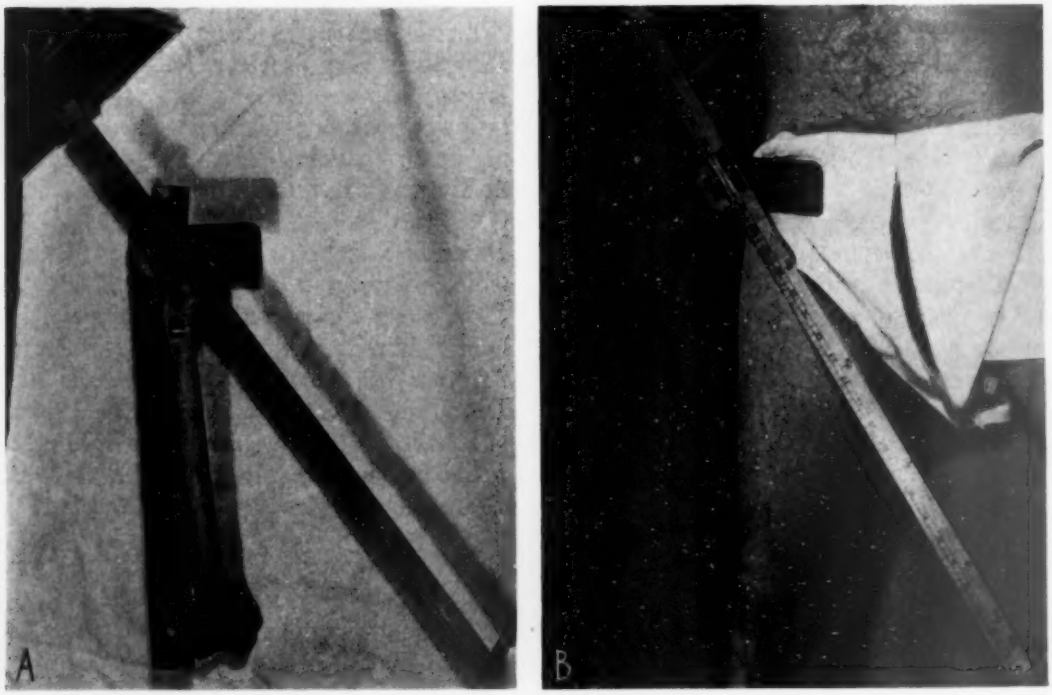

Fig. 1. *A*, the path of the central ray is indicated by the ruler placed in the metal sleeve. The angle of 128 degrees is obtained by setting the metal sleeve at a 38 degree angle to the long arm of the T-square. The outer side of the short arm of the T is removed to make the apparatus easier to handle. *B*, the apparatus in use on a patient. The location of the cassette and roentgen tube becomes apparent. Note that the thigh is held in slight external rotation.

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thigh and setting the film close to his flank.[3] Still another technique employs a curved cassette set in the patient's crotch, making the exposure from a point lateral to the involved hip.[4]

The need for a device which would quickly and accurately determine the path of the central beam and the position of the cassette became apparent to us while studying patients whose legs could not be maneuvered and under circumstances in which a portable roentgenographic apparatus had to be used. The device described here enables us to obtain true lateral roentgenograms which can be readily reproduced in a manner easily adaptable to operating room and bedside procedures.

To obtain accurate results it is necessary that the central ray traverse the femoral neck perpendicularly, projecting that structure in a parallel plane on the film. Our method makes use of the fact that the angle formed by the femoral shaft and neck is consistently close to 128 degrees. Further, it is easy to outline the shaft of the femur between the greater trochanter and external condyle, two readily determined fixed points. If a T-square is set with the greater trochanter within the right angle and the end of the long arm of the T against the external condyle, the angle of 128 degrees can be obtained by setting a metal sleeve at a 38 degree angle to the long arm of the T-square ($90° + 38° = 128°$). Then if a ruler is inserted so that it slides in the metal sleeve the course of the central ray is apparent. At each end of the ruler a 3 inch perpendicular bar is set. The central ray is directed from a point 3 inches beneath the ruler between the patient's legs to the cassette, which is placed so that its center corresponds to the distal end of the smaller bar and flush to it. In this way parallel relationships are established between the femoral

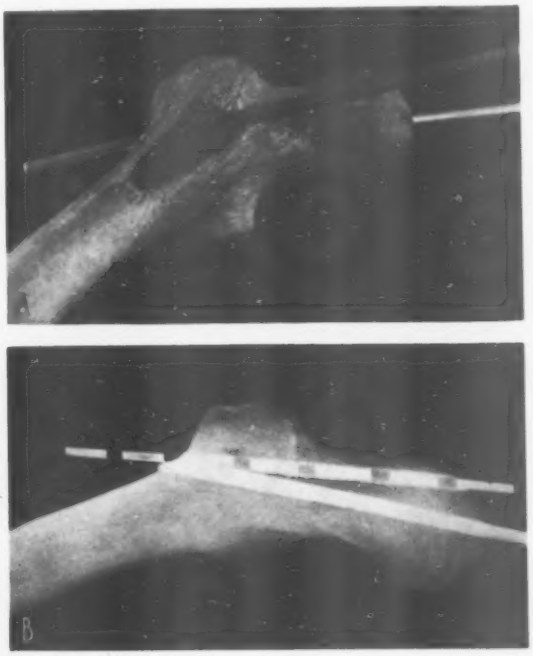

Fig. 2. *A*, the solid metal pin transfixes the femoral neck satisfactorily, and the dotted pin passses through the greater trochanter but outside the femoral neck. *B*, on the roentgenogram taken in the same position both pins appear to transfix the femoral neck. The specimen had been positioned by another roentgenologist as for a routine lateral film of the femoral neck.

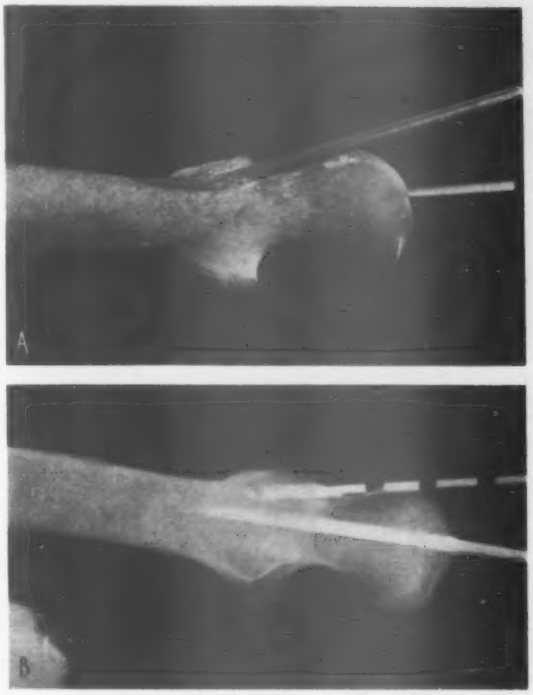

Fig. 3. *A*, photograph of the specimen positioned with the aid of the apparatus. *B*, roentgenogram showing that the dotted pin lies outside the femoral neck.

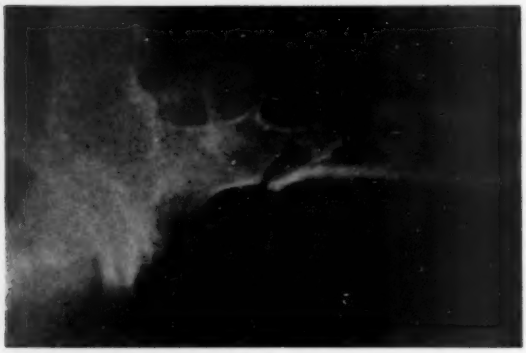

FIG. 4. Lateral roentgenogram of a fractured femoral neck obtained at the patient's bedside with the use of the apparatus described.

neck, the cassette and the target of the roentgen tube.

We have found it advantageous to keep the involved thigh in slight internal rotation. It is usually necessary to place the cassette as deeply as possible in the patient's flank. Better roentgenographic detail is obtained by using a fixed grid such as the Lysholm grid. We use a 30 inch target-film distance. To use the apparatus the opposite leg is elevated by an attendant. The apparatus is applied as directed and the position of the tube and cassette determined. Then the apparatus is removed and the exposure made.

In order to study roentgenograms made with the help of our device and films made with a comparable technique, an anatomic specimen was prepared with two metal nails. One passed through the femoral neck properly, the other transfixed the greater trochanter but passed above and outside the femoral neck itself. Photographs and roentgenograms were made after another roentgenologist had positioned the roentgen apparatus and femur as he would a patient for a routine lateral film of the femoral neck. Similar studies were made using our device. The results show how one might erroneously assume that the femoral neck had been transfixed on the film made with the usual technique relying on visual measurements alone.

REFERENCES

1. Cleaves, E. N. Observations on lateral views of hips. Am. Roentgenol. & Rad. Therapy, 1938, *39*, 964–966.
2. Johnson, C. R. New method for roentgenographic examination of upper end of the femur. *J. Bone & Joint Surg.*, 1932, *14*, 859–866.
3. Wittek-Saltzberg, R. Ueber seitliche Aufnahmen des Schenkelhalses und der Trochanterregion. *Röntgenpraxis*, 1932, *4*, 965–968. Quoted by Sante, L. R. Manual of Roentgenological Technique. Edwards Brothers, Inc., Ann Arbor, 1940.
4. George, A. W., and Leonard, R. D. Ununited intracapsular fractures of femoral neck roentgenographically considered. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 433–441.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

NECK AND CHEST

McGuffin, W. H. Observations gleaned from clinical and radiological chest examinations of recruits. *Radiology*, April, 1941, *36*, 413–420.

This article is based on the examination of the roentgenograms of 10,000 recruits from the southern half of the Province of Alberta. In Canada they make roentgenograms of the chest in the standing posteroanterior position with 14 by 17 inch films, target-film distance 6 feet, exposure one-tenth of a second or less, focal spot of the tube 4 mm. or less. They have not adopted the photofluororoentgenographic method.

The consultant radiologist works in collaboration with the lung, heart and surgical specialists. Clinician and radiologist should examine doubtful films together and should work together in the fluoroscopic examination. The heart as well as the lungs should be examined. Patients with patent ductus arteriosus, if the blood pressure is normal, would probably be fit for service in Canada but those with patent interauricular septum, hyperthyroid heart, syphilitic aortitis, hypertension and arteriosclerosis, rheumatic valvular disease with failure, and rheumatic aortic stenosis and regurgitation are unfit for any military service.

A healed minimal tuberculosis, if it has occurred within five years, makes a man unfit for military service. Even an apparently quiescent process may become active at any time and such patients are unfit for active service. Patients with pulmonary fibrosis without any impairment of function may be classified as fit for service in Canada; if there is any evidence of infection the recruit is unfit for any service. In fibrosis with pneumoconiosis, even if tuberculosis can be ruled out, the subject is not fit for more than service in Canada. The subject with chronic bronchitis with emphysema is unfit for any service. A subject with healed empyema with thickened pleura, râles and shortness of breath is not fit for military service. If the pleurae are thickened without evidence of lung disease the subject may be fit for service in Canada. If the subject has been operated on five years or more previously for empyema, is in good health with no evidence of lung disease and the pleura only mildly thickened he is fit for active service. Patients with lung tumor, benign or malignant, are unfit for any service.

The roentgenologist has a great responsibility in these examinations and he needs the assistance of both clinical and roentgen consultants in making decisions. This careful examination of recruits, though time-consuming and expensive, saves the country a great deal of money as compared with the admission of recruits unfit for service.—*Audrey G. Morgan.*

Møller, P. Flemming. The silicosis problem. *Radiology*, April, 1941, *36*, 482–485.

The author believes that the commonly accepted opinion that tuberculosis is the most common and most serious complication of silicosis is a mistake. Of course infection should be avoided as the silicotic lung is less resistant than the normal one, but the calcification that occurs does not make it an especially favorable soil for the development of tuberculosis. Rapidly progressive forms of silicosis are more susceptible to tuberculosis than others. Illustrative roentgenograms are given showing pictures very like those of tuberculosis but they were really due entirely to silicosis and the patient had no clinical signs of tuberculosis. Emphysema bubbles may simulate a tuberculous cavity. Emphysema may produce pneumothorax, resulting in the patient's death.

Spontaneous pneumothorax and paralysis of the heart are the two complications of silicosis that threaten the patient's life the most. Any affection of the respiratory tact is a serious risk for these patients because so much of the functioning lung tissue has been lost.

The author studied 798 porcelain workers in 1932 and found that 18 had third degree silicosis. Five years later 8 of these patients are dead, 7 of them from affections of the air passages.

Silicosis is a social problem which should be given much more serious attention than has been given it in the past. Various prophylactic

measures can be introduced but in some industries it is a more or less unavoidable hazard. —*Audrey G. Morgan.*

Albot, Guy; Brouet, Georges; Le Canuet, Roger, and Parturier-Lannegrace, Mme. Monique. Résultats du dépistage radiologique systématique de la tuberculose pulmonaire chez les jeumes chômeurs de la région parisienne. (Results of systematic roentgen examinations for pulmonary tuberculosis in the young people of the Paris region.) *Presse méd.*, May 14–17, 1941, *49*, 527–529.

Systematic roentgen examination was made of the lungs of 5,009 young people of the Paris region, 3,814 of them being young working people of both sexes from sixteen to twenty years of age of the poorest class and the rest students and nurses good up to thirty or even thirty-five years of age. All of them were apparently in good health. Among the whole group of 5,009, fifteen cases of active pulmonary tuberculosis were found, or 3 per thousand, while 59 cases of old undiagnosed tuberculosis, or 11.8 per thousand were found. Among the 3,814 young working people alone there were 8 cases of progressive tuberculosis or 2.1 per thousand. The lower percentage in the young working people is remarkable but it may have been due partly to the fact that, as a group, they were younger, and the group was larger. The figure for them was slightly higher than that found for the army and for the lower grades in school.

These mass examinations are obviously of value in withdrawing infected persons from association with their companions and thus preventing the spread of the disease. It may be that the adoption of the method of photographing screen pictures will settle the problem, but the cost even of ordinary roentgenography is low as compared with what is saved in the care of patients. It is not as yet known how often these examinations should be repeated. It will probably take some years to show the decrease in morbidity resulting from the treatment of infected persons.—*Audrey G. Morgan.*

Fiessinger, Noël, and Fauvet, Jean. Le poumon leucémique. (The leukemic lung.) *Presse méd.*, Apr. 29, 1941, *49*, 449–451.

A case is described in a woman of forty-nine who entered the hospital with the typical picture of myeloid leukemia; the leukocyte count was 520,000 with 90 per cent myelocytes. An enormous retroperitoneal hematoma containing about 2 liters of blood developed and she died.

She had had no lung symptoms but physical examination showed scattered râles at the bases and a roentgenogram was made. It showed the diaphragm pushed up by the enlarged spleen and liver and rounded cavities in both upper lung fields. The rest of the parenchyma was strewn with scattered nodules. The picture resembled that of bilateral ulcero-nodular tuberculosis. Histological examination, however, showed a picture quite different from that of tuberculosis. Some of the vessels were completely obliterated by organized clots adherent to the walls. The lung parenchyma was infiltrated with leukemic blood, and the myelocytes, which have a very great proteolytic action, had evidently brought about disintegration of lung tissue around the infarcts, producing the cavities shown in the roentgenogram. The lung changes were evidently of long standing and it is remarkable that they had caused no symptoms. It is not known whether such lung changes are frequent in myeloid leukemia. In one of the two cases seen since this one the lungs were found normal and in the other there were only a few scattered nodules. Nevertheless the association is worth further study.—*Audrey G. Morgan.*

Clark, K. C., Cordiner, G. R. Mather, and Ellman, Philip. Experiments in x-ray screen photography with control direct radiographs. *Brit. J. Radiol.*, Feb., 1941, *14*, 54–62.

The authors describe the details of the technique for photographing the fluorescent screen image on small photographic film, the 35 mm. cinema film being commonly used, and the enlargement of this miniature image. The chief value of this method is to detect early tuberculous lesions that cannot be detected by physical examination and to apply it in mass examination of recruits and perhaps also in industry. To obtain technically correct miniature films and to interpret them correctly requires close cooperation of expert technician, radiologist and chest physician.

A discussion follows of 80 cases in which such miniature roentgenograms were made and compared with the usual direct roentgenogram. The roentgenograms of both types are reproduced, showing the very great degree of agreement

between the two methods. There were only 8 cases in which there was a discrepancy between the miniature film and the ordinary direct film. In one case the direct examination showed a lesion unsuspected in the miniature. In 4 cases the full-size film disproved the presence of a lesion suspected in the miniature, though it must be said that in 2 of these cases it is possible that the lesion did not exist at the time of the miniature examination. In one case an Assmann focus was suspected on the miniature and confirmed on the direct film, in one case an active lesion suspected on the miniature was disproved on the direct film and in one the exact nature of a lesion unidentified on the miniature was shown by the direct examination.

The authors believe this method can be extended to heart examinations.—*Audrey G. Morgan.*

Shanks, S. Cochrane. Mass radiography of the chest, *et alia*. *Brit. J. Radiol.*, Feb., 1941, *14*, 45–53.

It has been found by examinations in various countries that roentgenography of the chest shows early active tuberculosis of the lungs in about 1 per cent of recruits who are apparently healthy and in whom the disease cannot be detected by clinical examination. Obviously it is important that these men be kept from enlistment. The cost of making roentgenograms of the chests of all recruits by ordinary methods would be prohibitive. It is therefore suggested that the examinations be made by the new method of miniature roentgenography. The fluorescent screen image is photographed on 35 mm. ciné film. When these are examined at the proper viewing distance the results are found to be almost as good as those of a contact print from a 15 by 12 inch negative. The method is cheap as 200 to 300 patients can be examined in an hour. Details of the technique with three types of apparatus, a German, a Dutch and a British are described.

The author outlines a plan for applying this method to the examination of all recruits. Details of the plan of organization are given. Of course skilled roentgenologists and chest physicians would be required for adequate carrying out of the scheme as interpretation of the films is of the greatest importance. The films should be filed at a central registry so that they could be reviewed and examined at any time.—*Audrey G. Morgan.*

Businco, Ottavio. Segno radiologico indiretto di adenopatia tracheo-bronchiale—Velatura parailare. (An indirect roentgen sign of tracheobronchial adenopathy—parahilar veining.) *Radiol. med.*, April, 1941, *28*, 203–209.

The frequency of tracheobronchial adenopathy in infancy is well known; it is found in about 85 per cent of autopsies on infants and roentgen examination frequently shows calcification of masses of glands in the mediastinal region. But up until recently it has been thought that this form of tuberculous adenopathy was rare in adults.

The author believes, however, that this supposed rarity is not real but is due to the fact that the diagnosis of this condition in adults is much more difficult than in young children. The form of tracheobronchial adenopathy seen in adults is generally not the massive caseous form seen in young children but is a hyperplastic form with a benign clinical course. The clinical signs are few and there are often no direct roentgen signs of the disease.

In such cases the presence of the adenopathy may be shown by a homogeneous veiling in the parahilar region, more or less marked and generally diffused toward the apex. In some of the cases which the author examined after some years there were calcified nodules in the hilar region showing the termination of the adenitis. This veiling should be interpreted in connection with such clinical signs as exist and is on the same side as the physical findings in unilateral cases.—*Audrey G. Morgan.*

Pruvost, P., Jacob, P., Delarue, and Depierre. Sur une forme particulière d'épithéliomas des grosses bronches, les "épistomes" bronchiques. (A special form of epithelioma of the large bronchi, epistoma of the bronchus.) *Presse méd.*, Oct. 21, 1941, *49*, 1140–1143.

Two cases of this special form of tumor are described and illustrated with roentgenograms and photomicrographs of the histopathological findings. One of the patients is at present well, after removal of the primary tumor and later of a recurrence; the other died of prolonged suppuration of the lung.

These tumors have been described under various names, such as angioma, endothelioma, adenomatous polyp, adenoma, and carcinoid. Berger in France in 1922 was the first to recognize that they were of the same nature as the

mixed tumors of the salivary glands. Different American authors have published about 50 cases since then. They generally run a course of about ten to twenty years before they cause death. At first there are no clinical signs; the first symptom is generally cough. In the majority of cases hemoptysis is the first alarming symptom. As the bronchus becomes more obstructed there is dyspnea. The condition is often mistaken for tuberculosis, asthma, sclerosis of the lung with adhesion of the pleura, bronchiectasis, or abscess of the lung.

The diagnosis can be made by lipiodol examination and bronchoscopy. The lipiodol is sometimes only arrested by the tumor, which is most often in the main branch of the bronchus, but it may outline the round, smooth tumor. If the diagnosis is made early enough the tumor can be removed through the bronchus by diathermic coagulation or implantation of radium needles. An effort must be made to remove the intramural part of the tumor, as it always originates in the wall of the bronchus, and though it may extend outside the bronchus and compress the lung it does not invade the lung parenchyma and it rarely if ever metastasizes. In some cases pneumectomy has been performed successfully by American surgeons.

The histopathological structure of these tumors is very complex. They are of the same nature as mixed tumors of the salivary glands, but neither one originates from displaced embryonic rests. They are a modified form of epithelioma with slow development, slight malignancy and slight tendency to metastasis and invasion. The authors propose the name of epistomas for them, this name being simply an expression of their chief characteristic of obstructing the bronchus.—*Audrey G. Morgan.*

Jamison, H. W. An anatomic-roentgenographic study of the pleural domes and pulmonary apices. *Radiology*, March, 1941, *36*, 302–314.

The anatomy of the pleural domes and the apices of the lungs is described with a view to showing that shadows may occur normally in the roentgenogram of these regions and that they do not necessarily indicate disease, much less tuberculosis. Diagrams and a roentgenogram are given showing the mechanism of production of the border shadows of the ribs. In addition to the shadows of the normal parts there are certain apical subpleural scars the cause of which has been very much discussed.

As a contribution to the discussion the author examined the apices of the lungs in 109 consecutive autopsies of persons fifteen years of age or more. The incidence of apical subpleural scars was found to be 27.6 per cent in persons under forty-five years of age and 68.8 per cent in persons older than that. Among 253 unselected chest films of persons fifteen years of age or more, apical subpleural shadows were found in 8.2 per cent of persons under forty-five years of age and 33.6 per cent of persons over that age. Obviously these scars increase with advancing age, which argues against their being tuberculous in origin. Bacteria of any kind may be carried to this region from the mouth or lungs by the lymphatics and naturally frequent invasions of bacteria over a long time would cause fibrosis of the subpleural lymphatics.—*Audrey G. Morgan.*

Troisier, Jean, Bariéty, M., and Monod, O. Les neurinomes intrathoraciques. (Intrathoracic neurinomas.) *Presse méd.*, Oct. 21, 1941, *49*, 1129–1131.

Two cases of intrathoracic neurinoma are described. These are benign tumors which cause few symptoms. Both of these cases were discovered by chance on roentgen examination, one in a boy, aged fourteen and a half, during a school examination and the other in a man of thirty-one on a general medical examination. The roentgen examination shows a large, dense homogeneous shadow, rounded and sharply circumscribed from the surrounding lung parenchyma; it is in the upper part of the thorax in 90 per cent of the cases; cases have been described in the middle and lower part of the thorax. In 98 per cent of the cases the tumors are posterior and laterovertebral, pressed close against the spinal column in the costovertebral groove. No projection shows the slightest clear band between the tumor and the vertebral column. The tumor is always absolutely adherent to the spinal column. Sometimes they have a prolongation into the spinal canal, forming an hour-glass tumor, partly inside and partly outside the canal. Both of the cases described here were of this type. Roentgenograms are given. These tumors are poorly vascularized and always have a nerve pedicle, making surgical excision easy.—*Audrey G. Morgan.*

Torelli, G. Il "segno dello scollamento" è patognomico per la cisti da echinococco? (Is the "detachment sign" pathognomonic

of echinococcus cyst?) *Radiol. med.*, March, 1941, *28*, 185–186.

The so-called "detachment sign" in echinococcus cyst is a clear half-moon above the upper pole of the cyst included between the convex surface of the mass and a delicate arch above it, continuous with the outline of the cyst. It is caused by a detachment between the adventitia and the membrana propria of the cyst.

This sign has been recognized by various authors as pathognomonic of echinococcus cyst of the lung. But the author holds that it is not as it has been seen in other conditions. He cites in support of his argument a case described by Dévé in *Arch. méd.-chir. de l'app. resp.*, 1928, *13*, 337. The patient was a man of twenty-five who had frequently had hemoptysis. The roentgenogram showed an oval shadow with the transparent half-moon described above. The biological reactions for echinococcus cyst were negative. After four years, as the hemoptysis persisted, a lobectomy was performed. The patient died. Autopsy showed a solid mass the size of an egg in a cavity in the parenchyma communicating with two bronchi, which was diagnosed as a bronchiectasis. The mass was made up of a dense group of mycetes of the *Aspergillus* family. Dévé proposed the name of "intrabronchiectatic megamicetoma" for the condition.—*Audrey G. Morgan.*

Rolnick, H. C., and Singer, P. L. Contralateral massive collapse of the lung in kidney surgery. *J. Urol.*, May, 1941, *45*, 678–681.

Massive pulmonary collapse following operative procedures is a well known entity. Three factors are of importance in its production: namely, position of patient during operation, preoperative medication, and anesthesia. Only a few cases of massive collapse following renal surgery have been reported. All have been on the opposite side from that operated on. The authors summarize the histories of 3 of the 6 cases which they have encountered during a ten year period.

In treatment they emphasize postural drainage, administration of drugs with a physiological effect opposite to that of atropine, and finally bronchoscopic removal of the obstructing plug of mucus if necessary. They feel that the occurrence of atelectasis following renal surgery is more common than suspected and is probably often overlooked.

Massive postoperative atelectasis following renal surgery is always on the contralateral side due to the elevated kidney rest which causes compression of the lung and consequent hypoventilation.—*R. M. Harvey.*

ABDOMEN

Ascroft, P. B., and Samuel, Eric. The x-ray diagnosis of acute intestinal obstruction. *Brit. J. Radiol.*, Jan., 1941, *14*, 11–22.

Two out of every 5 patients with acute intestinal obstruction die and the chief cause of this high mortality is late diagnosis. The authors studied 57 cases with a view to determining the value of plain roentgenography in decreasing this high mortality. They conclude that plain roentgenograms of the abdomen are indicated in all cases of obstruction. A combination of distinct fluid levels and a corresponding degree of distention of the small or large bowel is proof of obstruction and is not seen in any other condition. If there is serious obstruction it can be diagnosed readily by roentgen examination, and a negative finding is just as decisive evidence that there is no obstruction. In 30 of this series of cases plain films showed the presence of serious obstruction, and this diagnosis was confirmed by operation or autopsy. Among the 27 cases in which obstruction was suspected clinically a correct negative diagnosis was made in 22 and urgent obstruction was excluded in the other cases. The obstruction can be localized accurately by means of plain films if in the jejunum or ileum and to within a few inches of the anatomical site in the colon, as was done in 16 of the 19 cases in this series. Volvulus of the colon shows a characteristic picture.

Measurement of the distended loops and the number of fluid levels present established an accurate method of grading the degree of the obstruction. Contrary to generally accepted opinion, there is a considerable degree of distention of the small bowel in many cases of obstruction of the large bowel. If there is any doubt as to the interpretation of the roentgen signs further films should be taken at intervals. An enema should not be given just before the roentgen examination as it may cause misleading fluid levels.—*Audrey G. Morgan.*

Bullo, Enzo. L'ernia diaframmatica destre. (Right diaphragmatic hernia.) *Radiol. med.*, May, 1941, *28*, 265–275.

Since diaphragmatic hernia was first demonstrated by Holzknecht in 1901 the subject has been studied quite thoroughly. Hernia of the diaphragm on the right side is not nearly so frequent as on the left side, partly because the development of the left side is completed later than that of the right and partly because on the left side there is no large organ like the liver to protect the points of least resistance. Eppinger, among 635 cases of hernia of the diaphragm, found 580 on the left side and 55 on the right, a proportion of about 10 to 1.

Hernia of the diaphragm may occur at any age from infancy to old age, in fact it may occur in intrauterine life. Hernia of the diaphragm may be congenital or acquired, the former being much the more frequent and the latter generally caused by trauma. The congenital cases may be embryonic or fetal.

The author reviews the cases of non-traumatic hernia of the right side of the diaphragm in adult subjects that have been described in the literature. The organs that most frequently herniate into the thorax are the transverse colon, the liver and stomach, and the hernial ring is generally parasternal in origin at the foramen of Morgagni.

He describes a case in a man of sixty-five who had shown no symptoms until a few months before his admission to the hospital when he began to have a feeling of weight in the region of the stomach with loss of appetite and acidity; sometimes he vomited a clear liquid not containing any food. He had lost a few pounds in weight. Roentgen examination showed the proximal part of the transverse colon herniated into the thorax, extending up to the clavicle when the patient was lying down but falling much lower when he stood up. The size and shape of the duodenum were changed by perivisceritis.

It is not possible by roentgen examination to differentiate between the different forms of diaphragmatic hernia, congenital or acquired, embryonic or fetal, traumatic or non-traumatic. In his case there was no history indicating trauma. The best that can be done is to demonstrate that there is a hernia through the diaphragm, determine what organs are involved and by means of pneumoperitoneum demonstrate whether there is a direct communication between the abdomen and the thorax and to locate the hernia well enough for guidance in any necessary surgical operation.—*Audrey G. Morgan.*

Roberts, F. Tonus. *Brit. J. Radiol.*, Dec., 1940, *13*, 428–430.

The author maintains that the use of the word tonus is very much abused in roentgen literature, especially with reference to the stomach. This error was first introduced by Schlesinger who classified stomachs as hypertonic, orthotonic and hypotonic, which means stomachs with excessive, correct or defective tonus respectively. But as a matter of fact tonus must be correct in all the types if the stomach is carrying out its functions. The so-called hypertonic stomach is really only one that occupies a high position, the orthotonic stomach is average in size and position and the hypotonic stomach is merely longer and therefore lower in position than the average. These three terms should be abolished as they have no clinical significance.

Tonus is often confused with peristalsis. Tonus is an inherent property of unstriated muscle but it may be influenced by impulses from the central nervous system. Gastric tonus is increased by stimulation of the vagus and decreased by stimulation of the sympathetic. The author doubts, however, whether stomach tonus is affected by the emotions as is often claimed.

Tonus cannot be excessive but it may be defective. It is doubtful whether defective tonus causes gastroptosis but when there is organic obstruction at the pylorus, tonus is at first decreased and finally lost entirely. This is a definite pathological condition in which the muscle fails to perform its function.—*Audrey G. Morgan.*

Copleman, B., and Sussman, M. L. Hepatic duct visualization following oral cholecystography. *Radiology*, April, 1941, *36*, 465–467.

Four cases are described in which cholecystography was performed for visualization of the gallbladder. Roentgenograms made fifteen and thirty-five minutes after giving a meal of three egg yolks showed the cystic, common and hepatic ducts. Visualization of the cystic and common ducts frequently results from this procedure but ordinarily the hepatic duct cannot be seen. Normally when the gallbladder contracts the sphincter of Oddi relaxes. This abnormal visualization of the hepatic duct is probably brought about by some disturbance of this mechanism. The clinical symptoms in these cases were very much like those that have been

described in biliary dyskinesia but this diagnosis cannot be made definitely without being confirmed by cholecystography. The roentgen finding here described tends to confirm a clinical diagnosis of biliary dyskinesia.—*Audrey G. Morgan.*

Kerley, Peter. A gall-bladder visualised by gas. *Brit. J. Radiol.*, Aug., 1940, *13*, 289–290.

A woman of fifty-two was sent to hospital with a history suggesting gallbladder disease. Oral cholecystography showed the gallbladder distended with gas. The gallbladder might have become filled with gas in three ways: (1) From infection by gas-forming bacilli. But there was no clinical evidence of such infection. (2) Passage of a stone into the duodenum with consequent atony of the ducts, allowing air to come up from the duodenum. But the ducts could not be seen and when a barium meal was given none of it entered the bile ducts. (3) Fistula between the gallbladder and colon or between the gallbladder and duodenum. But on roentgen examination no fistula of either of these types could be seen. Operation, however, showed a fistula large enough to admit the little finger between the gallbladder and the proximal third of the transverse colon. The gallbladder was full of facetted stones. Evidently the acute attack had been caused by the passage of one of these stones through the fistula.—*Audrey G. Morgan.*

Barclay, I. B. Two unusual gastro-intestinal cases. *Brit. J. Radiol.*, Aug., 1940, *13*, 273–278.

Two cases with apparently rare gastro-intestinal lesions are described. The first was in a man of sixty-eight admitted to the hospital with symptoms from which a clinical diagnosis of carcinoma of the stomach was made. Roentgen examination did not show tumor or ulcer niche. The barium did not pass through the pylorus. There was no biloculation and no incisure on the greater curvature. During palpation with one mouthful of barium the shadow disappeared. A fistula could not be seen and the author did not then know that such a fistula could occur without biloculation. Operation showed a chronic ulcer of the stomach and a gastroduodenal fistula opening into the fourth part of the duodenum immediately proximal to the duodenojejunal flexure. Few such cases are described in the literature. The author thinks the fistula might have become visible if he had continued making examinations with single mouthfuls of barium. The difficulties of diagnosis on roentgenoscopic examination when fistula is not suspected and when it is located well back on the posterior wall are evident.

The second case was one of colloid gastric carcinoma with metastases only in the bones and lungs. The abdominal organs were not involved. The patient, a man of thirty-four, was admitted to the hospital for fracture of the clavicle and cough and pain in the lungs. He had never had any gastrointestinal symptoms and no roentgen examination of the digestive tract was made. He had a typical leuko-erythroblastic anemia which improved under treatment in spite of the rapidly progressive carcinomatosis.

Autopsy showed adenocarcinoma with well differentiated tubular structure and mucoid degeneration of the stomach. The case shows the importance of examining the digestive tract when the site of a primary tumor cannot be determined.—*Audrey G. Morgan.*

Boriani, Giuseppe. Il metodo del "progressivo riempimento" per l'indagine radiologica dello stomaco. (The method of "progressive filling" for the roentgen examination of the stomach.) *Radiol. med.*, March, 1941, *28*, 183–184.

There are certain advantages in filling the stomach entirely for roentgen examination and certain others in introducing only a small amount of contrast medium which is distributed as uniformly as possible over the walls of the stomach to show details in regard to mucous membrane relief. The author has found that his method of "progressive filling" combines to a certain extent the advantages of the two methods. When he has found the region of the stomach that is suspected of being the site of a lesion he takes a series of four roentgenograms of this region, giving the opaque paste progressively so that on the first roentgenogram the stomach is almost empty, on the second it contains a little more opaque medium, on the third it is half full and on the fourth entirely full. Such a series of roentgenograms is reproduced. In Figure 4 there was an image that suggested a niche of the upper third of the lesser curvature, but in Figure 1 this was seen to be only a special arrangement of the mucosal folds around the bolus. Figure 2 showed a rigid

tract in the lower third of the lesser curvature which was shown in Figure 1 to hide a large flat niche.

The method is simple and the author thinks very useful in many cases.—*Audrey G. Morgan.*

Connolly, A. E. Tuberculosis of the stomach. *Brit. J. Radiol.*, Oct., 1940, *13*, 351–353.

Tuberculosis of the stomach is a rare disease. A case is described in a woman of forty-five who came to hospital with symptoms suggesting cancer of the stomach. The sputum was negative for tubercle bacilli and a roentgenogram of the chest did not show any significant findings. The roentgenogram of the stomach seemed to confirm the clinical diagnosis of cancer. Postmortem examination showed tuberculosis of the stomach. There were five ulcers about the middle of the lesser curvature and two small caseous masses near the pylorus between the peritoneal and muscular coats. Microscopic examination showed the ulcers lined with caseating tuberculous material in which tubercle bacilli were found.

Other cases from the literature are discussed which illustrate the difficulty in differential diagnosis between cancer and tuberculosis of the stomach. Definite diagnosis can be made only after repeated clinical and roentgen examination.—*Audrey G. Morgan.*

Golden, Ross. Abnormalities of the small intestine in nutritional disturbances: some observations on their physiologic basis. *Radiology*, March, 1941, *36*, 262–286.

In this Carman lecture the author discusses a phase of the roentgenology of the intestinal tract in which Dr. Carman was so much interested. He selected for his topic the roentgen and clinical findings in deficiency states and believes that a closer study and correlation of the clinical and roentgen findings would result in earlier treatment of these nutritional disturbances and prevention of the later and irreversible stages.

The anatomy of the normal small intestine is discussed and a roentgenogram of the normal intestine given. The deficiency states may be primary, without obvious anatomical cause, such as celiac disease and non-tropical sprue, or they may be secondary to diseases of the gastrointestinal tract, mesentery, liver or pancreas. The clinical manifestations are very variable. The only proof that a diagnosis of a deficiency state is correct is that the patient responds to specific vitamin therapy. Many of the patients had diarrhea, anemia, abdominal pain and loss of weight. But diarrhea does not necessarily occur in vitamin B deficiency.

The roentgen changes seen are hypermotility and hypertonicity in the early stages, and in the advanced stages hypomotility and dilatation, especially in the duodenum. There is also often abnormal segmentation. The mucosal folds are coarsened in the earlier stages and often obliterated in the later stages, giving a smooth wall. The barium shadow may be flocculated in advanced cases.

Four cases showing these changes are described and illustrated with roentgenograms. In addition to the atrophy of the various layers of the intestinal wall seen in these conditions, in one of these cases degenerative changes were demonstrated in the intramural nerve cells of the wall. Great stress is laid on this point and it is believed that interference with intramural nerve function may be the common factor in these varied cases. The importance of vitamin B in nerve function has been proved. Specific changes in the absorptive capacity of the intestinal wall also appear to be associated with deficiency states.

Normal newborn infants show an intestinal pattern very similar to that seen in advanced deficiency states in adults. This is probably due to the fact that the nervous control of the intestine is not developed in the infant.—*Audrey G. Morgan.*

Geyman, M. J. Carcinoma of the jejunum. *Radiology*, April, 1941, *36*, 468–470.

Carcinoma of the jejunum is quite rare, more so than that of the duodenum. The symptoms depend on the degree of obstruction caused by the tumor.

A case is described in a woman of sixty-one. She had had indigestion for a year, loss of 11 pounds in weight and abdominal distention with cramps for six weeks. Roentgen examination showed the stomach and cap of the duodenum normal. Beyond the cap the duodenum was greatly dilated and the dilatation extended about 30 inches beyond the duodenojejunal junction. At this point there was a ring-like stenosis and below that the caliber of the jejunum was normal. Five hours later the stomach was empty and most of the opaque material was in the jejunum, only a little of it having

passed the obstruction. A probable diagnosis of carcinoma was made and confirmed on operation. A probable diagnosis of carcinoma was made and confirmed on operation. The patient died the day after the operation, probably from heart disease. Two mesenteric lymph nodes adjacent to the tumor were involved.

In the discussion Dr. Kirklin said that the difficulty in diagnosing these relatively rare tumors lay in determining when the time-consuming examination of the small intestine should be made, rather than in demonstrating the tumor when it was made. The clinical symptoms are common to a number of other conditions and the possibility of carcinoma of the jejunum is apt to be overlooked. Dr. Chas. Mayo shortly before his death reviewed the malignant tumors of the small bowel seen at the Clinic and found them situated most frequently in the jejunum, next the duodenum and last the ileum. Physicians should bear the possibility of this form of tumor in mind. With the latest roentgen techniques lesions which change the internal relief of the bowel can generally be demonstrated and many of them can be identified.—*Audrey G. Morgan.*

Weintraub, Sydney, and Tuggle, Allan. Duodenal diverticula. *Radiology*, March, 1941, *36*, 297–301.

The authors studied 310 cases with 249 duodenal diverticula. One of their objects was to determine whether duodenal diverticula, which are sometimes the only finding in a gastrointestinal examination, are the cause of the symptoms, which may vary from mild indigestion to severe pain.

It is not particularly difficult to demonstrate the diverticula, though in one case a diverticulum could not be seen either on the screen or on the film in two examinations; it could be seen on both on a third examination, and on a fourth and fifth was again invisible.

Examination of these cases confirmed the common belief that diverticulum of the duodenum is often associated with other congenital anomalies. Diaphragmatic hernia was found in 9 per cent of these cases, whereas it was only found in 2 per cent of more than 4,000 unselected gastrointestinal examinations. Often there were multiple lesions such as hernia, duodenal and colonic diverticula in 10 cases, diverticulosis of the esophagus, duodenum and colon in 2 and hernia and diverticulosis of the esophagus, duodenum and colon in one.

Four cases are described and illustrated with roentgenograms. There was no conclusive evidence in any of the cases that the symptoms complained of were caused by the diverticulum. In 14 cases in which autopsies were done there were no pathological changes in the diverticulum, and Horton and Mueller of the Mayo Clinic examined 212 duodenal diverticula found on autopsy and none of them showed inflammation. The authors do not believe that surgery is indicated for these diverticula.

In the discussion Dr. Kirklin said that duodenal diverticula are not to be taken too seriously and they are of value chiefly as an evidence that a thorough examination of the duodenum has been made. Dr. Frère asked if they had ever seen any diverticula of the appendix and Dr. Tuggle replied that they had not, but Dr. Taylor reported that in one case of appendectomy he had found a diverticulum of the appendix. He thinks they are rare.—*Audrey G. Morgan.*

Bloom, Arthur R. The roentgen diagnosis of duodenal ulcer. *Radiology*, March, 1941, *36*, 287–296.

Roentgen examination has shown that ulcer of the duodenum is much more frequent than that of the stomach, instead of much less frequent as was formerly believed. The diagnosis of duodenal ulcer should be made by careful use of both fluoroscopic and roentgenographic methods. The author describes his technique in detail and describes and illustrates a compressor and a serialograph which he himself has devised to take the place of the more expensive devices on the market.

The only direct sign of duodenal ulcer is the niche. He has been able to demonstrate this in 50 to 60 per cent of cases with special compression technique. The other pathognomonic signs, such as irregularity of shape of the cap, eccentricity of the pyloric canal, star-shaped fold and diverticula, are due to secondary changes. The most frequent sign is deformity of the cap.

Examination should not be limited to the stomach and duodenum. Arens and Bloom found that in 56 per cent of cases there are other pathological conditions in the digestive tract.

In the discussion Dr. Geyman said that some form of compression is necessary in the diagnosis of most duodenal ulcers. The important thing is not the form of compressor used but how it is used. With continued use of compression the percentage of cases in which niche can

be demonstrated will increase. Åkerlund now has a record of 75 to 80 per cent which is the highest reported. Dr. Geyman himself has a record of only 65 per cent. He has not seen multiple duodenal ulcers often; coexistent stomach and duodenal ulcers are more common. The apical ulcer is sometimes overlooked. It can be shown better with compression than without it.

Dr. Jenkinson said that he believed that in the presence of irritable bulb, even without niche, if gallbladder and other extraduodenal lesions can be ruled out, duodenal treatment should be given. Dr. Bloom agreed with this, defining irritable bulb as one that fills and empties so rapidly that it is impossible to get a filled bulb.—*Audrey G. Morgan.*

Williams, E. Rohan. Gastro-colic and gastro-jejuno-colic fistula. *Brit. J. Radiol.*, Jan., 1941, *14*, 36–40.

Five cases of gastro-colic and gastro-jejuno-colic fistula are described and illustrated with roentgenograms. The importance of using the barium enema rather than the barium meal for the demonstration of these cases is emphasized. Great care must be taken in giving the enema if the tract of the fistula is to be shown. With a rapidly filling colon and free passage of the barium into the stomach the overlapping of the opacities generally prevents demonstration of the track.

In only 1 of these 5 cases was the fistulous track shown. The patient was a woman of thirty-eight who had had ulcerative colitis for ten years. When she was given a barium meal the roentgenograms showed no abnormality of the stomach and it emptied in three and one-half hours. But the twenty-four hour film showed barium outlining the rugae of the stomach. As she had not taken any opaque medication since the meal twenty-four hours before it was obvious that the barium had re-entered the stomach from the region of the splenic flexure. A barium enema was given which showed the fistula from the colon into the stomach.

It is possible for a gastro-colic fistula to be overlooked by both oral and enema methods.—*Audrey G. Morgan.*

Boriani, Giuseppe. Applicazioni di anatomo-radiografia; la sede della nicchia nella imagine radiologica dell'ulcera duodenale bulbare. La "regola della stella a tre punte." (Anatomical applications of roentgenography: the site of the niche in the roentgen image of ulcer of the bulb of the duodenum. The "rule of the three-pointed star.") *Radiol. med.*, April, 1941, *28*, 227–232.

In Åkerlund's classical description of ulcer of the bulb of the duodenum the ulcer is located on the lesser curvature and the roentgenogram shows a niche at this site. But autopsy has shown many cases of true duodenal ulcer in which the roentgenogram did not show such a niche and in which a clinical diagnosis of periduodenitis had been made. As a matter of fact, in the majority of cases ulcer of the duodenum is not located on the lesser curvature but in the middle of the anterior or posterior wall. Ulcer of the greater curvature is rare. As a means of discovering these ulcers on the wall the author recommends the rule of the three-pointed star. If a three-pointed star is drawn with one tip at the lateral recess, one at the medial recess and one at the apex of the bulb the image of the niche should be found in the center of the roentgenogram where the three rays of the star meet. Roentgenograms and diagrammatic drawings illustrating this rule are given.—*Audrey G. Morgan.*

Ostrum, H. W., and Miller, Russel F. Calcified mucocele of the appendix, with rupture. *Radiology*, March, 1941, *36*, 356–361.

Free and encysted gelatinous masses are sometimes found in the peritoneum, resulting in the female from rupture of pseudomucinous cysts of the ovary and in males from rupture of a distended mucocele of the appendix.

The authors describe a case of calcified mucocele of the appendix in a man of seventy-three who was hospitalized from March 9 to March 28, 1936, complaining of general weakness and difficulty in moving his arms and legs. He was readmitted August 29, 1938, and died on September 5. Roentgen examination showed a large, irregular calcified tumor in the right lower quadrant. It was freely movable, not connected with the kidney or ureter and had produced a pressure defect in the cecum. Autopsy showed a collapsed mucocele of the appendix with fistulae into the rectum, sigmoid, cecum, ileum and bladder. No remnant of the appendix could be found.

This case is interesting from the fact that it is the first case of calcified mucocele of the appendix reported and that collapse of the tumor was demonstrated with discharge of its gelatinous, mucoid, semifluid contents into neighboring viscera.

These mucoceles can rarely be demonstrated by roentgen examination for the opening into the cecum is not patent and opaque material does not pass into the cyst. One case of patency with roentgen demonstration during life has been reported. Not only must there be patency for roentgen demonstration but the sac must be empty or partially empty or no contrast fluid can enter.—*Audrey G. Morgan.*

Brodin, M. L'appendicite chronique: son diagnostic par la palpation abdominale verticale et son retentissement duodénal avec arrèt au "genu inferius" mis en évidence par l'étude radiologique de la traversée digestive. (Chronic appendicitis: its diagnosis by abdominal palpation in the standing position and its effect on the duodenum with arrest at the lower flexure, shown by roentgen examination of the digestive tract.) *Presse méd.*, June 11–14, 1941, *49*, 619–621.

Thousands of people die every year of acute appendicitis. Many of these deaths could be prevented by the detection and treatment of chronic appendicitis, thereby preventing the acute attack.

The diagnosis of chronic appendicitis can generally be made by palpation with the patient standing and by examination with a barium meal of the whole of the digestive tract. Chronic appendicitis does not generally show localized pain but is manifested by gastric and hepatic symptoms, to such an extent that it has been said that if a young patient has gastric disturbance it means that he has appendicitis. Patients are generally examined for appendicitis in the dorsal position; it should be made with the patient standing for often there is pain in this position when there is none with the patient lying down, and if there is a pain point in the dorsal position it moves down lower when he is standing.

The roentgenogram shows delayed emptying of the stomach, and particularly of the duodenum; this is brought about by the propagation of the inflammation from the appendix to the lower flexure of the duodenum by way of the rich lymphatics of this region. A diagram is given of the lymphatics and a roentgenogram illustrating the stasis at the juncture of the second and third parts of the duodenum. This stasis with dilatation above it is almost pathognomonic of chronic appendicitis. The roentgen examination also shows movement of the pain point with movement of the point of attachment of the appendix to the cecum, and in about a third of the cases the appendix itself is shown.

During the late war the author made a diagnosis of chronic appendicitis in this way in more than 800 cases; in all of the cases operated on the diagnosis was confirmed. In more than 30 per cent of them the appendix was retrocecal. Some of the patients refused operation; a certain percentage of these later had an acute attack of appendicitis and in the others the symptoms persisted.—*Audrey G. Morgan.*

Archer, Vincent W., and Cooper, George, Jr. Intra-abdominal hernia or intestinal incarceration: two verified cases pre-operatively diagnosed. *Radiology*, April, 1941, *36*, 458–464.

Paraduodenal or intra-abdominal hernia was described by Neubauer 163 years ago but not much attention has been paid to it since. A little over 200 cases have been described but most of these were found by chance on operation. Only 4 have been diagnosed by roentgen examination before operation. The authors report 2 further cases so diagnosed.

The first was in a young man of twenty-one who complained of pain of the ulcer type and recently of vomiting, nausea and anorexia. He had lost 12 pounds weight in two months. Roentgen examination showed a mass of loops of jejunum on the right side in a rounded area which exercised pressure on the stomach. This was thought to indicate paraduodenal hernia, which was confirmed on operation. There was a sac bounded above by the ligament of Treitz, anteriorly by the superior mesenteric vessels, below by the cecum and its peritoneal attachments and behind by the parietal peritoneum. Several loops of jejunum had passed into this sac which was large enough to admit a man's fist after the intestines were removed. The loops were removed and the sac obliterated by suture. The patient made an uneventful recovery and has had no recurrence.

The other case was also in a man of twenty-one. The roentgen examination showed pylorospasm and loops of jejunum matted together in a rounded mass below the liver and to the right of the midline. Examination nine days later showed the jejunum in normal position. Apparently in this case there was a fossa into which the loops of intestine passed at times and were released at other times.

These paraduodenal hernial sacs are formed by folds of peritoneum, the exact cause of which is not known. The theories in regard to it are discussed. These 2 cases were both on the right side, though about three-fourths of the reported cases have been on the left side.

In all cases of pain associated with nausea and vomiting in which no lesion is found in the esophagus or stomach, films should be taken every hour until the whole of the small intestine has been examined. Examination should be made if possible during an attack in order to discover cases such as the second one. In this case while the bowel was incarcerated there was a 50 per cent six hour residue. On the second examination there was no residue.—*Audrey G. Morgan.*

Williams, E. Rohan. The radiological findings in two unusual cases of inguinal hernia. *Brit. J. Radiol.*, Jan., 1941, *14*, 41–42.

Two unusual cases of inguinal hernia are described and illustrated with roentgenograms. In the first in a man aged twenty-nine, the only contents of the small hernial sac was a chronically inflamed appendix which was demonstrated by strapping a lead letter to the finger and exploring the inguinal canal. In the second case in a man of seventy-nine the scrotum was occupied by at least 30 inches of large gut. It is interesting to speculate on what might have happened if a sigmoid volvulus had occurred.—*Audrey G. Morgan.*

Barenberg, L. H., Greene, D., and Greenspan, L. Congenital megacolon (Hirschsprung's disease); report of a case treated with acetylbetamethylcholine bromide, with apparent cure. *J. Pediat.*, May, 1941, *18*, 579–586.

Congenital megacolon is believed to be due to an imbalance of the autonomic nerve supply of the colon. Sympathetic nerves from the first and second lumbar segments of the spinal cord innervate the distal colon. Preganglionic fibers from the first and second lumbar segments pass to the inferior mesenteric plexus and postganglionic fibers from this plexus pass to the colon.

The rectal sympathetics are in the presacral nerve of Latarjet which divides in the pelvis into two hypogastric nerves which join the hypogastric ganglia whose postganglionic fibers pass to the lower rectum, the internal sphincter of the anus and the pelvic viscera. The circular muscle fibers of the rectum are also supplied by sympathetic nerves. Stimuli from the lumbar sympathetics inhibit the colon and increase the tone of the rectal sphincter. The parasympathetics from the lower sacral segments increase the tone of the intestine and relax the internal sphincter. There are also intrinsic mesenteric plexuses which conduct nerve impulses and correlate muscular activities. Thus inhibitory effect leading to constipation may result from either stimulation of the sympathetics or relaxation of the parasympathetics.

Acetylbetamethylcholine is a parasympathetic activator. The authors report a case of megacolon studied from the age of three months to the age of four and one-half years. When first seen the patient had abdominal distention and constipation. Barium enema examination revealed a marked generalized dilatation of the colon. Numerous drugs were tried for the next three years, pituitrin being the only one of any value. At this time a lumbar sympathectomy and ganglionectomy was performed but no relief resulted. Four months later mecholyl was tried for the first time in 1 milligram hypodermic doses. This had some temporary beneficial effect but it was not until oral acetylbetamethylcholine was started that definite lasting results were obtained. The maintenance dose was 200 mg. daily. This resulted in three daily bowel movements and relief of distention. The caliber of the bowel showed marked improvement by barium enema examination. The authors do not claim that a permanent cure has been effected.—*R. M. Harvey.*

McCullough, J. A. L., and Sutherland, Charles G. Intra-abdominal calcification: the interpretation of its roentgenologic manifestations. *Radiology*, April, 1941, *36*, 450–457.

In roentgenograms of the abdomen unexpected calcifications are often seen. An effort should always be made to interpret them. Two films should always be made, either for stereoscopic use or with just a slight shift of the tube so the relative change of position of calcium deposits may be noted. Sometimes a lateral view is helpful in determining the nature of such a deposit.

In the right upper quadrant calcium deposits may be seen in the renal and biliary tracts and in the pancreatic, adrenal, subdiaphragmatic and paravertebral areas. Modern methods have

made it possible to diagnose kidney and gallbladder concretions almost without fail. But a case is shown in which a C-shaped shadow at the notch of the liver represented a stone impacted in the cystic duct. Calcification in the walls of a non-functioning gallbladder generally shows the complete outline of the organ. Such lesions may be confused with a large rounded stone in the pelvis of the right kidney. Rotation of the patient, a lateral view or a urogram will clear up the diagnosis. Occasionally calcification in the walls of a pancreatic cyst may simulate a calcified gallbladder. These cysts, however, are behind the gallbladder and generally much further to the left. Echinococcus cysts of the liver may also simulate calcified gallbladder. Stones in the pancreas, particularly in the head, may cause some confusion. In the lateral view stones in the head of the pancreas lie in the mid-abdominal region, while those in the body and tail extend upward and backward toward the body of the first lumbar vertebra. Calcifications of the intervertebral discs in the upper abdominal region may simulate pancreatic stones but a comparison of the anteroposterior and lateral roentgenograms should show their true nature. Occasionally calcification is seen in a lymph node in the bile tract near the notch of the liver. Calcification in a liver abscess generally lies higher than any other type of calcium deposit except one in subphrenic abscess. Anteroposterior and lateral projections generally show the position of the abscess in the liver. Calcifications in the costal cartilages may be confusing but they generally run downward and laterally from the sternum to the ends of the ribs.

In the left upper quadrant the most frequent calcium deposits are in the spleen. They may be phleboliths or tuberculomas. Calcium deposits may form around the spleen in various infections. In the right lower quadrant the most frequent type of calcification, aside from those in the ribs, is that in mesenteric lymph nodes. Another type of paravertebral calcification is that which follows suppuration of the lumbar or lower thoracic vertebrae as in tuberculous or typhoid spondylitis.

The appendix is a favorite site for foreign bodies. Probably the commonest type of calcification in the pelvis is that occurring in the vessels. Calcification is frequently found in ovarian cysts, particularly dermoids, in teratomas in other situations and in lithopedion. None of these should present any particular difficulty in diagnosis.—*Audrey G. Morgan.*

Fray, Walter W. Roentgen manifestations of arteriosclerosis of the branches of the abdominal aorta, with particular reference to calcification of branches of the coeliac axis. *Radiology*, April, 1941, *36*, 439–449.

Calcification of the walls of the arteries of the celiac axis is frequently seen in old people, especially on the left side. The shadows are generally in the left upper quadrant, while the right, or hepatic branch, rarely shows calcification. The shadows generally represent an incomplete circle. The calcified segment may be large or small. Straight plaques alone are rarely seen.

A series of 12 cases seen by the author are described and illustrated with roentgenograms. All except one of the patients were more than sixty years old; this exception was a diabetic woman fifty-five years of age. The condition was found more frequently in women than in men. A third of the patients were diabetics. Therefore if such shadows are seen examination for diabetes should be made if not made already. These patients frequently showed calcification of other arteries also.

Roentgenologists who have not seen these shadows before often make a wrong diagnosis and unnecessary operations are performed. Calcified aneurysm may be identified in some cases and failure to diagnose a ruptured aneurysm may postpone a needed operation.

As roentgenography improves with the use of rotating targets these shadows will be seen more frequently in elderly patients.—*Audrey C. Morgan.*